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Studies on Olividae. XV. Anterior notch measurements as taxonomic characters in the genus *Oliva*.

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KEYWORDS. Mollusca, Gastropoda, *Oliva*, taxonomy, morphometry, anterior notch.

MOTS-CLEFS. Mollusca, Gastropoda, *Oliva*, morphométrie, taxonomie, échancrure antérieure.

ABSTRACT. Four novel measurements of the anterior notch are defined and their potential for *Oliva* taxonomy evidenced. Reproducibility of measurements and causes of error have been studied.

RESUME. Quatre nouvelles mesures de l'échancrure antérieure sont définies et leur potentiel pour la taxonomie du genre *Oliva* est mise en évidence. La reproductibilité des mesures et les causes d'erreur ont été étudiées.

1. INTRODUCTION

Shell morphometry appears to be the most practical, objective approach to the taxonomy of the genus *Oliva*. Sets of protoconch measurements (TURSCH & GERMAIN, 1985 and 1986), teleoconch measurements (TURSCH & GERMAIN, 1985) and measurements of the subsutural groove (TURSCH & VAN OSSELAER, 1987; VAN OSSELAER & TURSCH, 1988) have therefore been defined and tested. These measurements have repeatedly been shown to be useful and reliable taxonomic characters (TURSCH, GERMAIN & GREIFENEDER, 1986a and 1986b; TURSCH & HUART, 1988; TURSCH & GREIFENEDER, 1989; TURSCH & GREIFENEDER, 1989; TURSCH & HUART, 1990; TURSCH, MISSA & BOUILLON, 1992).

Our search for additional shell characters has led us to test the possibilities offered by measurements of the anterior notch, which is conspicuous in all Olividae (see Fig. 1).

The anterior notch does not possess any sharp discontinuity that could be utilized as obvious pointers and repeated attempts at direct measurements on the shell (TURSCH & GERMAIN, unpublished results) have been shown to lack both precision and reproducibility. Indirect measurements are far more convenient and we wish to report here that accurate observations can be made on imprints of the anterior canal. The present paper aims solely at defining these measurements and testing their taxonomic potential.

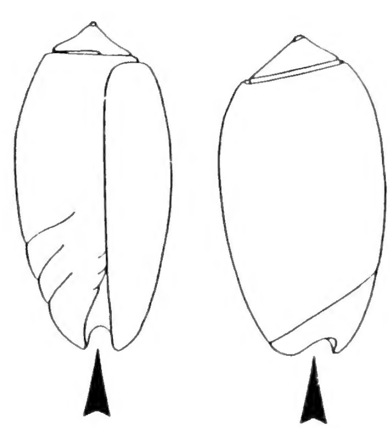

Fig. 1. Ventral and dorsal view of an *Oliva* shell. The arrows point at the anterior notch.

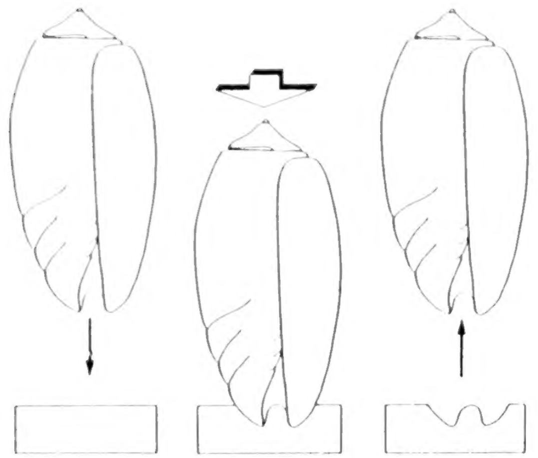

Fig. 2. Making a modelling clay imprint of the anterior notch of an *Oliva* shell.

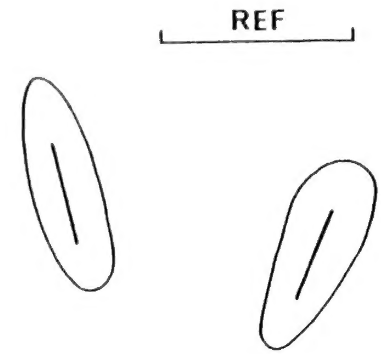

Fig. 3. Typical imprint of the anterior notch of an *Oliva* shell. REF is 1 mm reference segment. The trace of the outer lip is at the left, that of the columellar lip at the right. The deepest part of each trace is also represented (see text, section 2.3).

2. METHODS

2.1. Making an imprint

The shell to be measured is presented vertically (apex up) and then carefully lowered upon a flat, horizontal surface of modelling clay (plasticine) (Fig. 2). One should ensure simultaneous contact of the lowest points of both the columellar lip and the outer lip with the clay surface. A very slight vertical pressure on the shell then yields an accurate imprint, consisting of two distinct traces of comparable size.

2.2. Drawing the imprint

The imprint is then carefuly drawn, using the *camera lucida* attachment of a binocular lens. The size of the drawing is controlled by adjusting the magnification to obtain a length of 2 to 5 cm for each trace. A segment of 1 mm is also drawn as an internal length reference, using a precalibrated ocular reticulum. The length of this reference segment on the drawing will be called **REF**.

2.3. Geometrical construction on the drawing

The deepest part of each trace is quasi-linear. It is carefully drawn for each trace (see Fig. 3), then graphically extrapolated by tracing the lines **a** and **b** (see Fig. 4). Line a is the direction of the lower edge of the outer lip and line b that of the lower edge of the columellar lip. Points **A**, **B**, **C** and **D** are defined as the intersections of lines a and b with the contours of the traces. Lines a and b intersect at point **G**.

Point **E** and **F** are defined as the midpoints of segments AB and CD, respectively (Fig. 5).

2.4. Measurements

Let us define (see Fig. 5) the linear measurement **DN** as EF/REF (where REF stands for the length of the 1 mm internal reference segment described hereabove). DN is thus the length of the segment EF, expressed in millimeters.

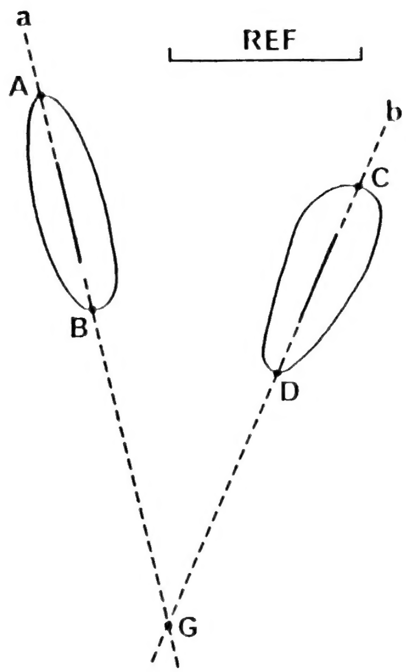

Fig. 4. First step of the geometrical construction on the drawing of the imprint (see text, section 2.3).

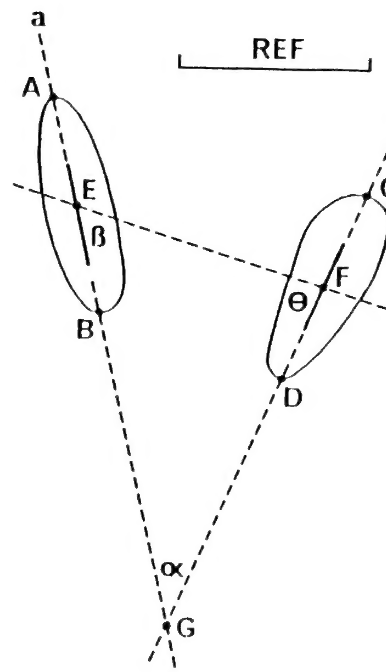

Fig. 5. Second step of the geometrical construction on the drawing of the imprint (see text, section 2.3).

Let us also define (see Fig. 5) the angular measurements **α** as the angle of the lines a and b; **ß** as the angle of the lines EF and EG; θ as the third angle of the triangle AFG. All angles are expressed in degrees. Determination of two of any of these angles automatically defines the third one, as their sum is equal to 180°.

The angles can either be measured with a protractor, or calculated from the lengths of the segments EF, EG and FG. For the latter case, a little, simplistic computer program based upon relations such as

$$\cos\beta = (EF^2+EG^2-FG^2)/2*EF*EG$$

instantly yields the desired angles.

The two methods (direct protractor measurements and calculation from the lengths of sides of the triangle EFG) have been compared by performing both types of measurements on ten photocopies of the same drawing. This was done both for a large (*Oliva porphyria*, specimen BT-0345, H [height]: 114 mm) and a small species (*Oliva hilli*, specimen BT-6206, H: 12 mm).

The results are given in Table 1. It can be seen that angles α, ß and θ are more accurate when calculated than when directly measured, especially when the angles are small.

2.5. Practical tips

Best results have been obtained by using dark colored modelling clay (the better contrast makes the drawing easier). The quasi-linear, deepest part of the trace is located nearly in the middle of the groove and is easier to observe on rather shallow imprints (where shade is no problem).

A minimum of practice is strongly advised before attempting actual taxonomic work; some training greatly decreases the dispersion of the measurements. For two series of ten measurements, separated by 30 other trials, the performance of a naive observer (expressed in CV) improved from 4.80 to 2.20 for the measurement of DN, from 14.68 to 7.14 for α, from 3.61 to 2.70 for ß and from 4.12 to 2.25 for θ , all angles being calculated as decribed above.

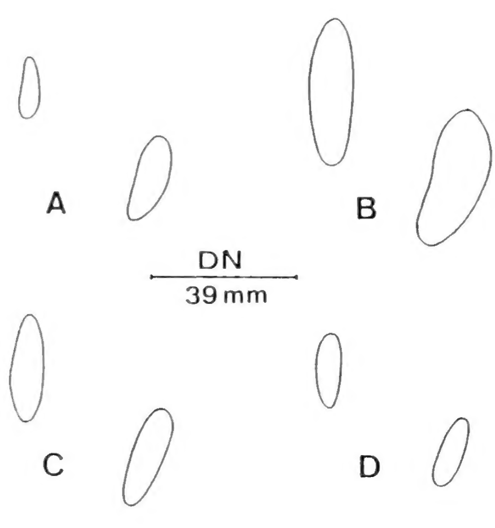

Fig. 6. Four imprints of the same shell (*Oliva sayana* BT-5315, H: 70.9 mm). The traces of the outer lip (length: OTR) are represented on the left, the traces of the columellar lip (length: CTR) are on the right. DN is 39 mm. Imprints vary both in size and in shape (see text, section 2.6). Imprints A and B are not recommended for measurements but imprints C and D do meet the requirements (see text, section 2.7).

2.6. Variability of imprints

The expressions "a very slight vertical pressure" (section 2.1) yielding "rather shallow imprints" (section 2.5) are very vague. There is no easy, practical way of measuring the pressure exerted on the shell or depth of imprint in soft material. In order to be reproducible, the process clearly needs a more accurate description.

For a given shell, the length of the traces is of course positively correlated with the depth of the imprint. Furthermore, as the *Oliva* shell is not a regular surface of revolution, it is to be expected that the shape of the traces will also vary with the depth of the imprint. The shape will also be affected with deviations to verticality. This is indeed the case as evidenced in Fig. 6 where the trace of the outer lip is represented on the left.

2.7. Choice of suitable imprints

If one produces a quantity of imprints of a given specimen on a slab of modelling clay, it will be seen at a glance that these imprints are very variable. The problem of which particular imprint to choose for measurements immediately arises. Imprints can be characterized by the absolute size of one trace (roughly proportional to the vertical pressure exerted on the shell) and by the relative size of the two traces (roughly dependent upon deviations from verticality). This will allow an empirical optimization of experimental conditions.

The graph of Fig. 7 shows the values of DN obtained for a series of purposely variable imprints obtained from the same shell (*Oliva sayana* BT-5315, H: 70.9 mm). Each imprint is characterized by the length (the largest diameter, not to be confused with AB or CD) of the trace of its columellar lip (**CTR**) and the length of the trace of its outer lip (**OTR**).

One sees that consistent values are obtained in a region where the lengths of both traces do not differ by more than 10 % and lie between 0.5 and 0.75 times the length of DN.

As an example, if we apply the above guidelines to the imprints depicted in Fig. 6, where DN is 39 mm, we can see that imprint A (OTR: 17 mm, CTR: 24 mm) should be

rejected because the lengths of its traces differ too much: CTR does not lie within the limits of OTR plus or minus 10%. Imprint B (OTR: 40 mm, CTR: 38.5mm) should be rejected because the traces are too large (more than 0.75 DN). Imprints C (OTR: 28 mm, CTR: 28 mm) and D (OTR: 19,5 mm, CTR: 18 mm) are adequate.

All these precautions might appear quite intricate but were needed mainly to avoid gross errors. In practice, the method is quite simple and very fast. It takes only seconds to produce a quantity of imprints of a given specimen and with a bit of experience, a suitable imprint will be recognized at first sight.

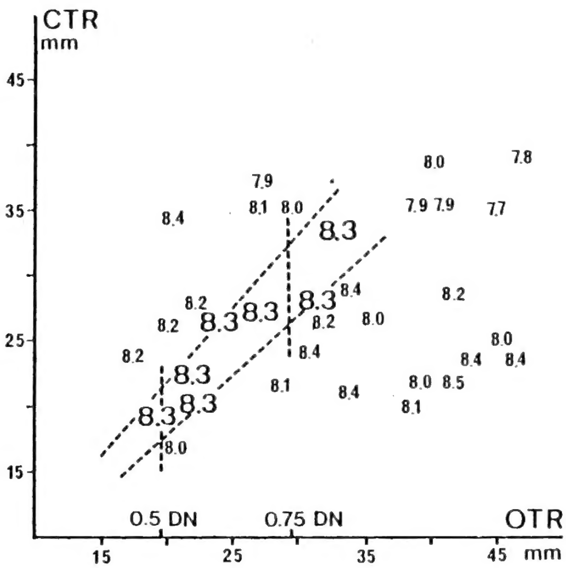

Fig. 7. Values of DN measured on a series of imprints obtained from the same shell (*Oliva sayana* BT-5315, H: 70.9 mm). To represent the variability, the values of DN are plotted for different lengths of the traces of the columellar lip (CTR) and the outer lip (OTR). The recommended working zone is delineated by broken lines (see text, section 2.7)

3. REPRODUCIBILITY and PRECISION

Before any taxonomic application, one has to assess the limits of confidence of these new measurements and to evaluate the relative contribution of the various possible sources of error.

The three consecutive phases of the process described hereabove can each lead to a different type of error:

A. error due to the inaccuracy of the geometrical construction and the measurements on the drawing.

B. error due to the inaccuracy of the drawing of the imprint.

C. error due to the non-reproducibility of the imprint process.

3.1. We have first compared the measurements performed by two independent observers on **ten photocopies of the same drawing**. In this case we deal only with error A. This was done both for a large (*O. porphyria*, specimen BT-345, height: 114 mm) and a small species (*O. hilli*, specimen BT-6206, height: 12 mm). The angles were obtained by calculation from the lengths of the sides of the triangle EFG.

The results are given in Table 2, where the dispersion of the data can be evaluated by the standard deviation S or the coefficient of variability CV, which is the standard deviation as percentage of the mean (MAYR, 1969). It can be seen that error A is very small and that the two observers obtained practically the same values.

3.2. We have then compared the measurements performed by two independent observers on **ten different drawings of the same imprint**. In this case we cumulate two types of error (A and B). This was done both for a large (*O. porphyria*, specimen BT-345, height: 114 mm) and a small species (*O. hilli*, specimen BT-6206, height: 12 mm). The results are given in Table 3.

3.3. Finally, we have compared the measurements performed by two independent observers on **ten different imprints of the same shell**. In this case we cumulate the three types

of error (A,B and C). This was done both for a large (*O. porphyria*, specimen BT-345, height: 114 mm) and a small species (*O. hilli*, specimen BT-6206, height: 12 mm). The results are given in Table 4.

3.4. In conclusion, the mean values obtained by separate observers are quite compatible: they differ by less than 0.1 mm on distances and 2° on angles. Their precision is also quite similar.

The contribution of the various types of error can be very roughly estimated by observing the evolution of the average values of the coefficients of variability (CV) obtained by two independent observers on the same shell during the three steps of the process. This was done both for a large (*O. porphyria*, specimen BT-345, height: 114 mm) and a small species (*O. hilli*, specimen BT-6206, height: 12 mm). The results are given in Table 5.

Errors of type A (geometrical construction and measurements on the drawing) are very small and probably negligible for practical purposes.

Excepted for α, the overall dispersions seem roughly independent of the size of the shell. The greatest dispersion is observed for α , which is a much smaller angle than ß or θ: the same angular error will result in a much larger relative error.

Errors of type B (inaccuracy of the drawing of the imprint) are by far the largest contributor to the total error on α. They are largely due to the extrapolation error when tracing lines a and b.

As only two of the three angles need to be determined (see section 2.4) it is preferable to select the larger angles ß and θ.

4. VARIATION WITH SIZE

Before attempting actual taxonomic work, one should first establish whether the measurements defined hereabove are dependent upon the size of the shell or not.

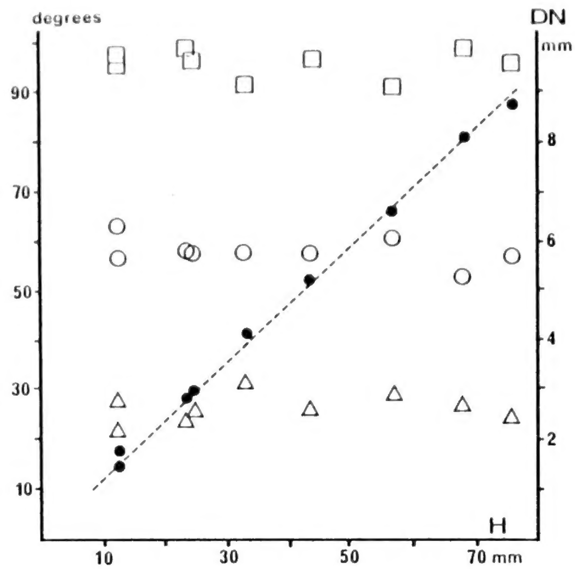

Fig. 8. Anterior notch measurements on a growth series of *Oliva sayana*. DN (black circles) increases linearly with the heigth of the shell (H). The angular measurements α (open triangles), ß (open circles) and θ (open squares) do not significantly vary with H.

The linear measurement DN (the width of the anterior notch) could be expected to be size-dependent. Indeed, DN increases linearly with the height of the shell (H) as shown in Fig. 8. DN is also correlated (not illustrated) with other linear shell measurements (the width D, the length of the lip L, etc ...). On the contrary, the angles α, ß and θ appear not to vary significantly with shell size.

As *Oliva* shells show considerable variations in size, it follows that DN values are better utilized under a reduced form (expressed as a ratio to some other linear shell measurement) such as DN/H or expressed as DN/pnw (pnw being the number of postnuclear whorls). For a given species, the angles α, ß and θ

should be treated as constants. It would indeed make little sense to utilize values as ß/pnw: it would simply amount to another expression of pnw, with the introduction of a supplementary error due to the measurement of ß.

5. TAXONOMIC APPLICATION

Discrimination tests utilizing only the measurements described here were performed on fifty *Oliva* species (unpublished), with encourageing results. To give an example amongst many others, the clear separation of five species on the basis of anterior notch characters alone (scatter diagram of DN/H versus ß) is shown in Fig. 9.

One should remember that only two of the angles α, ß and θ should be utilized at the same time in the biometric analysis of a given species (the third angle being necessarily redundant).

6. DISCUSSION

The measurements described hereabove are quite easy and fast (less than 5 minutes). Their precision and reproducibility have been proven satisfactory. The anterior notch has been shown to yield stable and operational taxonomic characters. At this stage, we do not know if these characters are significant at another level than specific.

One of the advantages of these characters is that the anterior notch region is habitually intact, even in severely damaged shells. These measurements do not require perfect specimens and could be performed on fossil material.

Anterior notch characters are not restricted to the genus *Oliva* and their use could be extended to other gastropod groups. Preliminary tests on other genera of Olividae (*Agaronia*, *Olivella*, *Olivancillaria*, *Ancilla*) yielded promising results (unpublished). Research along these lines is being pursued in our laboratory.

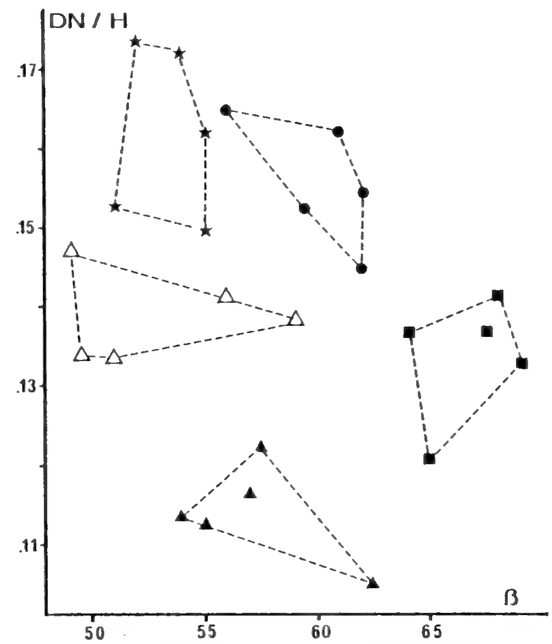

Fig. 9. Separation of five *Oliva* species on a scatter diagram of ß versus DN/H. Minimum convex polygons. Stars: *Oliva bulbiformis*; black circles: *O. carneola*; open triangles: *O. bulbosa*; black triangles: *O. australis*; black squares : *O. dubia*.

7. MATERIAL EXAMINED

"JS-" specimen numbers refer to shells in the J. Senders collection and "BT-" to shells in the B. Tursch collection (both in Brussels).

Oliva australis Duclos, 1835. AUSTRALIA: BT-1476 and BT-1478 (no loc.); BT-3600 (Brighton); BT-5301 (Freemantle); BT-4506 (Yorke).

O. bulbiformis Duclos, 1835. INDONESIA, Bali: JS-028, JS-029, BT-1549 and BT-1551. PHILIPPINES: BT-1556 (Bohol).

O. bulbosa Röding, 1798. ABU DHABI: BT-4604, BT-4605, BT-4606, BT-4607 and BT-4608.

O. carneola Gmelin, 1791. SOLOMONS: BT-0301 (Guadalcanal); BT-2516 (Langalanga); BT-2548, BT-2549 and BT-2553 (no loc.).

O. dubia Schepman, 1911. PAPUA-NEW GUINEA: BT-4928, BT-4929, BT-4930, BT-4931 and BT-4932 (Hansa Bay, 50 m).

O. hilli Petuch & Sargent, 1986. TONGA: BT-6026 (Vava'u I.).

O. porphyria Linnaeus, 1758. W. MEXICO: BT-0345 (Bahia San Augustino, Sonora).

O. sayana Ravenel, 1834. U.S.A., Florida: BT-6671 (no loc.); BT-5315, BT-5316, BT-5318, BT-4072 and BT-4074 (off Cape Canaveral); BT-4094 and BT-4098 (Sanibel I.); BT-4097 (Tampa Bay); BT-0944 (Marco Beach); BT-6672, BT-6673, BT-6674 and BT-6675 (Port St. Joe Bay).

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	O. porphyria			***O. hilli***		
	mean	*S*	CV	mean	*S*	CV
α(m)	36.22	0.89	2.46	18.20	0.50	2.77
α(c)	36.12	0.50	1.38	17.91	0.27	1.53
ß(m)	58.57	0.77	1.31	61.43	0.74	1.21
ß(c)	58.39	0.60	1.02	61.35	0.55	0.90
θ (m)	85.70	0.67	0.79	100.95	0.68	0.68
θ (c)	85.54	0.37	0.43	100.76	0.73	0.73

Table 1. Comparison of two methods of obtention of angles α, ß and θ. Test on ten photocopies of the same drawing (imprints of *Oliva porphyria*, specimen BT-345, H: 114 mm and *Oliva hilli*, specimen BT-6206, H: 12 mm). Angles are in degrees. (m) indicates angles directly measured with a protractor, (c) indicates angles calculated from the sides of triangle EFG. *S* is the standard deviation and CV is the coefficient of variation.

	Observer B			**Observer O**		
	mean	*S*	CV	mean	*S*	CV
Oliva porphyria						
DN	13.81	0.07	0.49	13.73	0.05	0.42
α(c)	36.12	0.50	1.38	36.09	0.50	1.38
β(c)	58.39	0.60	1.02	58.13	0.19	0.33
θ(c)	85.54	0.37	0.43	85.69	0.58	0.67
Oliva hilli						
DN	1.50	0.01	0.63	1.49	0.01	0.69
α(c)	17.91	0.27	1.53	17.99	0.26	1.45
β(c)	61.35	0.55	0.90	60.78	0.41	0.67
θ(c)	100.76	0.73	0.73	101.22	0.52	0.51

Table 2. Evaluation of error A (see text, section 3.1). Statistics on ten measurements performed by two independent observers on ten photocopies of the same drawing (imprints of *Oliva porphyria*, specimen BT-345, H: 114 mm and *Oliva hilli*, specimen BT-6206, H: 12 mm). Angles are in degrees, DN in mm (c) indicates the angles are calculated (see text). *S* is the standard deviation and CV is the coefficient of variation.

	Observer B			**Observer O**		
	mean	*S*	CV	mean	*S*	CV
Oliva porphyria						
DN	14.36	0.13	0.92	14.32	0.10	0.72
α(c)	32.05	2.53	7.88	32.99	2.21	6.70
β(c)	55.24	1.49	2.70	53.14	1.28	1.54
θ(c)	92.71	1.98	2.14	93.86	1.54	1.64
Oliva hilli						
DN	1.46	0.13	0.92	1.46	0.01	0.82
α(c)	20.89	1.59	7.93	19.54	1.75	8.97
β(c)	63.17	1.27	1.85	61.16	0.86	1.34
θ(c)	96.74	1.85	1.91	99.30	1.34	1.35

Table 3. Evaluation of error A+B (see text, section 3.2). Statistics on ten measurements performed by two independent observers on ten different drawings of the same imprint (*Oliva porphyria*, specimen BT-345, H: 114 mm and *Oliva hilli*, specimen BT-6206, H: 12 mm). Angles are in degrees, DN in mm, (c) indicates the angles are calculated (see text). *S* is the standard deviation and CV is the coefficient of variation.

	Observer C			Observer O		
	mean	*S*	CV	mean	*S*	CV
Oliva porphyria						
DN	14.20	0.21	1.46	14.27	0.27	1.88
α(c)	29.11	1.69	5.81	30.90	1.57	5.07
β(c)	57.15	1.57	2.74	55.34	1.28	2.31
θ(c)	94.05	1.84	1.95	93.75	1.25	1.34
Oliva hilli						
DN	1.53	0.03	2.00	1.49	0.03	1.83
α(c)	20.30	2.66	13.09	19.66	2.30	11.68
β(c)	59.32	1.14	1.93	60.86	1.87	3.06
θ(c)	100.47	3.44	3.42	99.48	3.01	3.03

Table 4. Evaluation of error A+B+C (see text, section 3.3). Statistics on ten measurements performed by two independent observers on ten different imprints of the same imprint (*Oliva porphyria*, specimen BT-345, H: 114 mm and *Oliva hilli*, specimen BT-6206, H: 12 mm). Angles are in degrees, DN in mm, (c) indicates the angles are calculated (see text). *S* is the standard deviation and CV is the coefficient of variation.

	error A	errors A+B	errors A+B+C
O. porphyria (114 mm)			
DN	0.46	0.80	1.67
α	1.38	7.29	5.44
β	1.19	2.12	2.53
θ	0.55	1.74	1.65
O. hilli (12 mm)			
DN	0.66	0.85	1.98
α	1.49	8.45	12.39
β	0.79	1.59	2.48
θ	0.62	1.63	3.23

Table 5. Contribution of the different sources of error to the total dispersion of measurements effected on the same shell. The values given are the average of the two coefficients of variability (CV) obtained by two independent observers (see Tables 2,3 and 4).

Studies on Olividae. XVI. Fasciolar region measurements as taxonomic characters in the genus *Oliva*.

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KEYWORDS. Mollusca, Gastropoda, *Oliva*, morphometry, fasciolar region, taxonomy.

MOTS-CLEFS. Mollusca, Gastropoda, *Oliva*, morphométrie, région fasciolaire, taxonomie.

ABSTRACT. Novel shell measurements of the fasciolar region of *Oliva* shells are defined. The reproducibility of these measurements has been tested and their potential for *Oliva* taxonomy evidenced.

RESUME. De nouvelles mesures de la région fasciolaire des coquilles d'*Oliva* sont définies. La reproductibilité de ces mesures ainsi que leur potentiel pour la taxonomie du genre *Oliva* ont été démontrés.

1. INTRODUCTION

Shell morphometry has been demonstrated to be a convenient, objective tool for the clarification of the complex taxonomy of the genus *Oliva* (TURSCH & GERMAIN, 1985, TURSCH, GERMAIN and GREIFENEDER, 1986a and 1986b; TURSCH and HUART, 1988; TURSCH and GREIFENEDER, 1989; TURSCH and GREIFENEDER, 1989; TURSCH and HUART, 1990, TURSCH, MISSA & BOUILLON, 1992).

The power of the biometrical approach increases with the number of available, operational, independent characters. The search for additional *Oliva* shell characters is thus a continuing endeavour in this laboratory (TURSCH & GERMAIN, 1985 and 1986; TURSCH & VAN OSSELAER, 1987; VAN OSSELAER & TURSCH, 1988; VAN OSSELAER & TURSCH, 1992).

We wish to report here on the possibilities offered by measurements of the fasciolar zone that is a conspicuous feature of all *Oliva* shells (see Fig. 1). Quantitative measurements in the fasciolar region are still unexplored in the genus *Oliva*, but have already been utilized as taxonomic characters for *Ancilla* by KILBURN (1981), who measured the width of the ancillid band and expressed it as a ratio against the width of the fasciolar band taken at the labium.

The fasciolar region has been described and discussed in detail by OLSSON (1956) for the genus *Olivella* and by KILBURN (1981) for the genus *Ancilla*. There is no detailed discussion of these features in the two latest review works on the genus *Oliva* (ZEIGLER & PORRECA, 1969 and PETUCH & SARGENT, 1986) and a short description of the fasciolar region of *Oliva* will thus be given hereunder.

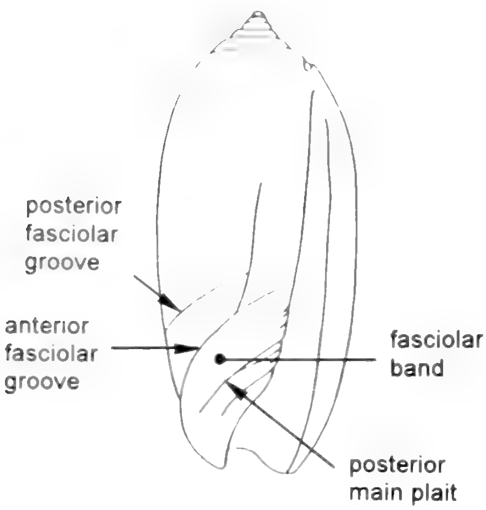

Fig. 1. General ventral view of an *Oliva* shell with characteristical features of the fasciolar region

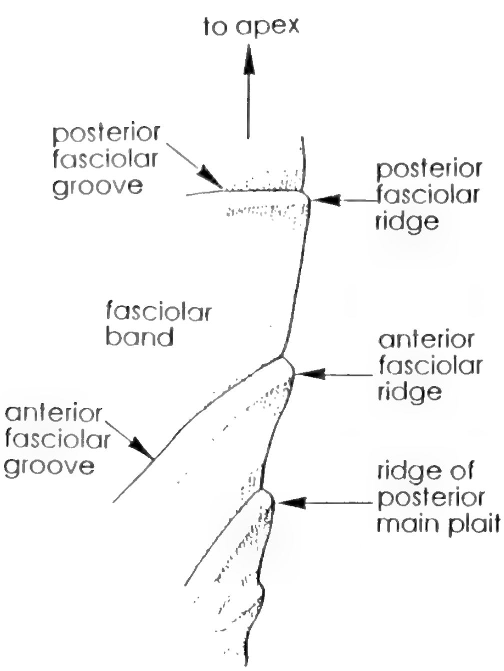

Fig. 2. Characteristical features of the fasciolar region of an *Oliva* shell. Greatly enlarged side view of the fasciolar region.

Fig. 1 provides a general ventral view and Fig. 2 a greatly enlarged side view of the fasciolar region of *Oliva* shells. In all *Oliva* shells, the anterior, ventral portion is sharply marked off by an incised line, the **posterior fasciolar groove**, closely followed by an abapical small raised edge, the **posterior fasciolar ridge**.

The anterior part of the fasciolar region is again marked off by another incised line, the **anterior fasciolar groove**, also closely followed by an abapical raised edge, the **anterior fasciolar ridge**.

Between the posterior and the anterior fasciolar grooves is a region called the **fasciolar band**. It often presents quite characteristical colour patterns. These have been utilized for instance for the description of *O. australis pallescens* and *O. kurzi* by PETUCH & SARGENT (1986) and for the distinction between *O. mantichora* and *0. amethystina* by TURSCH, GERMAIN & GREIFENEDER (1986b).

The anterior region delimited by the anterior fasciolar groove is the **fasciole**, covered by a thick callous growth. This is a very obvious feature: its texture contrasts conspicuously with that of the remainder of the shell and its colour is also different. The fasciole is crossed by one or several prominent spiral ridges, which are the continuation of columellar plaits. The most adapical of these prominent ridges is called here the **posterior main plait**.

Only a very few *Oliva* possess additional sculpture. As described by OLSSON (1956): "In most species of *Oliva*, the fasciolar band is similar to that of *Olivella* but in some special groups such as *Strephonella*, *Omogymna* and *Lamprodomina*, an extra callous band of variable size is added above, and which is sometimes so wide that it extends across the parietal wall nearly to the suture."

The terms "posterior fasciolar groove", "anterior fasciolar groove" and "fasciolar band" are utilized here *sensu* KILBURN (1981). The terms "posterior fasciolar ridge", "anterior

fasciolar ridge" and "posterior main plait" are new definitions.

The present paper aims solely at defining novel shell measurements in the fasciolar region and at testing their taxonomic potential for the genus *Oliva*.

2. METHODS

2.1. Positioning the shell

It is very difficult to obtain reproducible direct measurements of the fasciolar features, especially on a small shell. This difficulty can be solved by making measurements on an enlarged, accurate drawing of a ventral view of the shell. In order to have reproducible drawings, it is of course crucial to observe the shell in a position that is itself reproducible.

Dorsal views of a given *Oliva* shell are highly reproducible. Indeed, when an *Oliva* shell is deposited aperture down on a flat surface it generally rests in a stable, reproducible position. In contrast, an *Oliva* shell deposited aperture up will roll quite freely on its rounded body whorl. The ventral views needed for fasciolar measurements are thus highly erratic unless special precautions are taken to ensure that one will always have the same ventral view of a given shell.

Several solutions to this practical problem have been tested. The simplest, and by far the most reliable consists in depositing the *Oliva* specimen aperture down on a glass plate of appropriate size. The shell is then firmly pressed in its "equilibrium position" against the glass plate by means of plasticine (for a small specimen) or rubber bands (for a large specimen). The glass plate is now turned upside down (with the shell now hanging below the plate), deposited on a suitable horizontal support (such as the rim of an open rigid plastic box) and brought under the binocular lens for examination. The shell is now viewed as in Fig. 3a.

2.2. Drawing the shell

The shell being properly positioned, a careful drawing can now be made with the help of the *camera lucida* attachement of the binocular lens. In practice, one does not have to draw the entire shell: only the indispensable features (designated by arrows in Fig.3b) are necessary. In order to give an internal reference for scaling the measurements is also necessary to draw a segment of known length, using a precalibrated ocular reticulum. The length of the drawing of a 1 mm segment will be called **REF**.

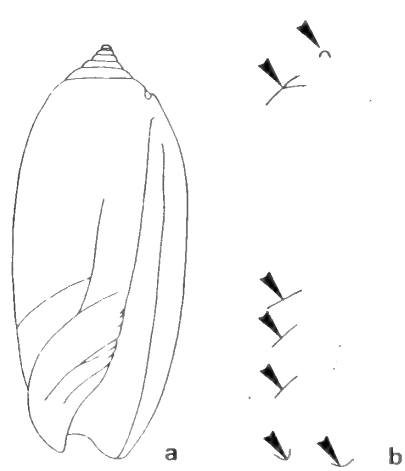

Fig. 3. Drawing the shell, after proper positioning. Fig 3a shows the shell as it is seen. Only the features indicated by arrows in Fig.3b have to be drawn.

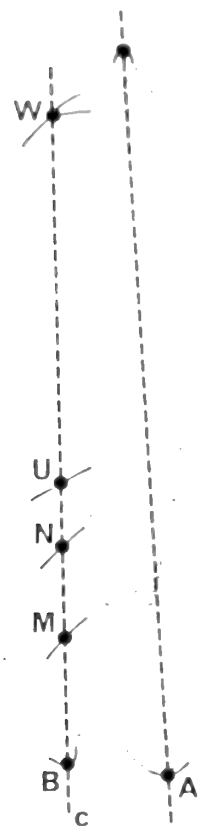

Fig. 4. Definition of measurements.

As depicted in Fig. 4, let us call **A** the most abapical (anterior) point of the outer lip and **B** the most abapical (anterior) point of the columellar lip. The tip of the apex is designated as **P**. The point where the outer edge of the penultimate whorl is seen to meet the body whorl (opposite the lip) is called **W**.

Let us call **c** the line joining B to W, **M** the intersection of line c with the ridge of the posterior main plait, **N** the intersection of line c with the anterior fasciolar ridge (just below the anterior fasciolar groove) and **U** the intersection of line c with the posterior fasciolar groove (see Fig. 2).

2.3. Measurements

Let us now define the measurements **PLI** as the real length of the segment BM (this is BM/REF), **LF** as the real length of the segment BN (this is BN/ REF), **UF** as the real length of the segment BU (this is BU/REF) and **BW** as the real length of the segment BW (this is BW/REF).

2.4. Practical tips.

It is important to check that the shell does not move. The drawing is facilitated if one directs a nearly horizontal light beam on the anterior part of the shell and rotates the object until maximum contrast is obtained on the posterior main plait and the anterior fasciolar ridge.

As for all linear measurements, the error is roughly proportional to the actual lengths measured on the drawing. One should thus try to make drawings as large as practicable. The size of the drawing can be controlled by adjusting the magnification of the binocular lens. Precision is increased if the shell is carefully centered in the lens field.

3. REPRODUCIBILITY and PRECISION

Errors on the drawing and on the geometrical construction have been shown to be practically negligible. Reproducibility and precision have been estimated by comparing the measurements performed by two independent observers on ten different series of measurements on the same shell. This was effected for a large shell (*Oliva miniacea*, H: 78.21 mm and a small shell (*Oliva hilli*, H: 12.00 mm). The results are given in Table 1, where the coefficient of variability CV (MAYR, 1969) can be utilized to estimate the dispersion of the measurements. It can be seen that the measurements of the two observers differ by no more than 0.67 mm for the 78.21 mm shell (0.86 % of the heigth of the shell) and by no more than 0.06 mm for the 12.00 mm shell (0.50 % of the heigth of the shell).

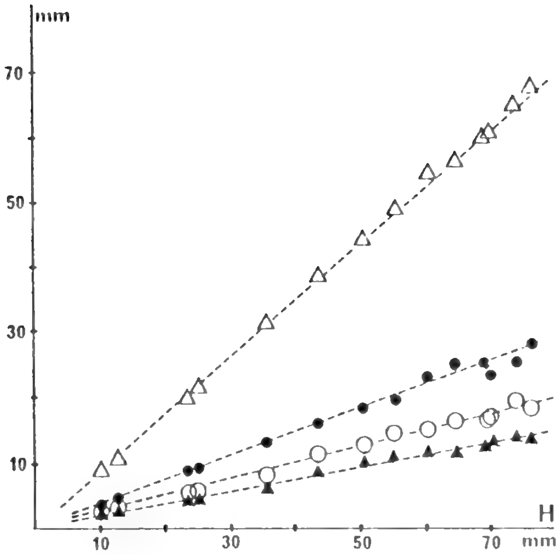

Fig. 5. Measurements on a growth series of *Oliva sayana* Ravenel, 1834. Variation of the measurements BW (open triangles), UF (black circles), LF (open circles) and PLI (black triangles) with the heigth of the shell H. All measurements in millimiters.

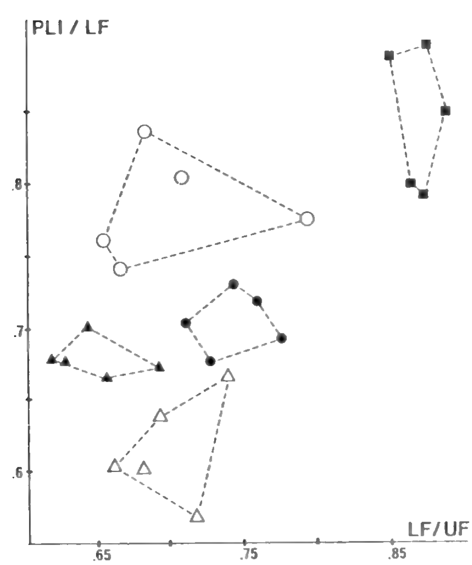

Fig. 6. Scatter diagram of LF/UF *versus* PLI/LF. Minimum convex polygons. Open triangles: *Oliva amathystina* Röding, 1798. Black squares: *O. dubia* Schepman, 1911. Black triangles: *O. hirasei* Kuroda & Habe, 1952. Open circles: *O. polpasta* Duclos, 1835. Black circles: *O. reticulata* Röding, 1798.

4. VARIATION WITH SIZE

Before attempting any taxonomic application one should first establish how the measurements defined hereabove are dependent upon the size of the shell. Measurements effectd on a growth series of *Oliva sayana* show that BW, UF, LF and PLI are practically proportional to the heigth of the shell H (see Fig. 5) and that the regression lines have a zero intercept with the axes. The measurements BW, UF, LF and PLI could also be expressed as a function of the number of postnuclear whorls pnw (TURSCH & GERMAIN, 1985).

Since the measurements BW, UF, LF and PLI are size-dependent, we can compare shells of different sizes only by utilizing ratios of these data to other linear measurements (such as H). Ratios of fasciolar measurements are of course valid.

5. TAXONOMIC APPLICATION

Numerical data constitute taxonomic characters only if their utilisation leads to effective discrimination of taxa. The fasciolar region has been measured on a number of *Oliva* species (to be published) and have been shown to be operational (alone or in combination with other measurements) in numerous species separations. Fig. 6 gives an example (amongst many others) of total separation of five species, using solely the fasciolar region measurements described above.

6. DISCUSSION

6.1. At first sight it could appear that the length of the segment AP would provide a more convenient internal length reference because AP is by definition the heigth of the shell H (TURSCH & GERMAIN, 1985), that is directly measured on the shell with a precision digital display calliper. Microscope measurements are true only if the measured segment lies exactly in the plane of observation (perpendicular to the optical axis).

In this case, the orientation of the line AP is not necessarily parallel to the observation plane. The observed segment AP is really the orthogonal projection of AP on that plane. Numerous trials have shown that AP is generally shorter than H (as expected) and differs by an average 2.5 %.

This remark applies to all the measurements defined here: all are projections of the true lengths on the observation plane. In particular, it applies to the distance AB, the true length of which has been previously defined as the measurement DN (VAN OSSELAER & TURSCH, 1992). AB is also the projection of DN on the observation plane (and differs from DN by an average 4.20 % in numerous trials). AB could however be of some use as an additional measurement because it could give information of the angle between DN and the observation plane in the "equilibrium position" of the shell (see 2.1).

6.2. The measurements described hereabove are quite easy and fast (less than 5 minutes per shell). Their precision and reproducibility have been proven satisfactory. The fasciolar region has been shown to yield stable and operational taxonomic characters.

One advantage of these characters is that the fasciolarian region is generally intact, even in severely damaged shells. These measurements do not require perfect specimens and can be performed on fossil material. Fasciolar measurements are not necessarily restricted to the genus *Oliva* and could presumably be extended to other groups in the Volutacea superfamily.

	Observer B			Observer O		
measurement	mean	S	CV	mean	S	CV
Oliva miniacea, H: 78.21 mm						
BU	71.79	0.11	0.15	71.44	0.23	0.33
UF	27.04	0.28	1.03	25.35	0.27	1.09
LF	18.53	0.28	1.49	17.86	0.33	1.87
PLI	12.70	0.40	3.17	12.17	0.21	1.75
Oliva hilli, H: 12.00 mm						
BW	10.27	0.04	0.41	10.21	0.06	0.62
UF	4.26	0.05	1.25	4.20	0.04	1.05
LF	3.09	0.03	1.10	3.05	0.06	2.23
PLI	2.19	0.02	0.93	2.15	0.05	2.64

Table 1. Series of ten independent measurements effected by two independent observers on the same shell (*Oliva miniacea* and *O. hilli*). Data in bold characters are actual lengths in mm on shell.

7. MATERIAL EXAMINED

"BT-" Specimen numbers refer to shells in the author's collection.

Oliva amethystina Röding, 1798. PHILIPPINES: BT-4494 (Mindanao); BT-4563, BT-4564, BT-4567 and BT-4570 (no loc.).

O. dubia Schepman, 1911. PAPUA-NEW GUINEA: BT-4928, BT-4929, BT-4930, BT-4931 and BT-4932 (Hansa Bay, 50 m).

O. hilli Petuch & Sargent, 1986. TONGA: BT-6026, Vava'u I.

O. hirasei Kuroda & Habe, 1952. PHILIPPINES: BT-5021, BT-5022 and BT-6202 (Sulu); BT-6194 and BT-6196 (Panglao).

O. miniacea Röding, 1798. PHILIPPINES: BT-6670 (no loc.).

O. polpasta Duclos, 1835. W. MEXICO: BT-0314, BT-0315 and BT-0316 (Baja California); BT-4613 (off Salina Cruz, Oaxaca). PANAMA: BT-3779 (Cebaco I.).

O. reticulata Röding, 1798. PHILIPPINES: BT-4594, BT-4596, BT-4597, BT-4598 and BT-6029 (no loc.).

O. sayana Ravenel, 1834. U.S.A., Florida: BT-6671 (no loc.); BT-5316, BT-5315, BT-5318, BT-4072 and BT-4074 (off Cape Canaveral); BT-4094 and BT-4098 (Sanibel I.); BT-4097 (Tampa Bay); BT-0944 (Marco Beach); BT-6672, BT-6673, BT-6674 and BT-6675 (Port St. Joe Bay).

Acknowledgements.

We are grateful to the Fonds National de la Recherche Scientifique (F.N.R.S) for supporting our research (F.R.F.C. grant n° 29008.90), to Dr. Dietmar Greifeneder who first called our attention on the problem, to Mr. Olivier Missa who helped to test the measurements and to Mrs. Nicole Van Mol who kindly helped with the shell drawings.

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New Cones from Oman and the status of *Conus boschi* (Gastropoda; Conidae) *

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ABSTRACT. *Conus boschorum* and *C. biraghii omanensis* are described as new to science. As far as we know both have a limited distribution (Masirah island and Hallaniyah Islands [=Kuria Muria Islands]). After studying additional material of *C. boschi* Clover, 1972, it must be considered a junior synonym of *C. melvilli* Sowerby III, 1879.

KEYWORDS: Gastropoda, Conidae, *Conus*, Oman, nomenclature.

INTRODUCTION

For over a century the Arabian Peninsula has been a major and mystical source of conchological treasures. In recent years knowledge of the molluscs of the Sultanate of Oman has increased after the publication of "Seashells of Oman" by Donald and Eloise BOSCH (1982). They discovered the special malacological richness of Masirah Island, which is situated in the Arabian Sea, just off the coast of Oman. This island has been visited by only a few shell collectors and from their findings we know that several endemic species occur there: *Cypraea teuleri* Cazenavette, 1846; *Conus boschi* Clover, 1972; *Acteon eloiseae* Abbott, 1973; *Latirus bonnieae* Smythe, 1985; *Conus stocki* Coomans & Moolenbeek, 1990. Other Masiran species are found on the neighbouring coast of Oman too, which can be explained by the fact that the island is only separated from the Arabian peninsula by a narrow strait of about 6 to 10 m depth.

Several years ago Dr D.T. Bosch showed us some small,worn cone shells from Masirah island, which at first sight we considered juveniles. When publishing on the family Conidae from Oman in detail (COOMANS & MOOLENBEEK, 1990) we had no idea to which *Conus* species these "juveniles" should be assigned.

In November 1991 the first author joined an expedition, initiated by Dr. Bosch, to obtain more material and new data concerning the malacofauna from the Oman coast. During a week of intensive collecting on Masirah Island, we discovered the habitat of these "juvenile" cones. They live subtidally in a bottom community with algae, sponges, and other invertebrates. No large specimens were collected. The only other sympatric *Conus* species were *Conus ardisiaceus* Kiener, 1845 and *Conus boschi* Clover, 1972. These facts gave rise to the idea that our "juveniles" should be considered as two small *Conus* species. After comparison with other Indo-Pacific species of the genus *Conus* we are convinced that both species belong to unnamed taxa which are described below. All material is deposited in the Zoölogisch Museum Amsterdam (University of Amsterdam), the Netherlands, unless otherwise stated.

*Studies on Conidae no. 17/ Studies on the marine molluscan fauna of Oman, no. 7.

TAXONOMY

Conus boschorum n. sp.
Figs 1-6, 17

Type Material. Holotype (figs 1-2) in Zoölogisch Museum Amsterdam(ZMA Moll. 3.92.001) and 370 paratypes (ZMA Moll. 3.92.002), partly preserved in alcohol. Paratypes will be distributed to the Oman Natural History Museum (Muscat), the National Museum of New Zealand (Wellington) and to the private collections of Dr. D. Bosch (USA), Dr. D. Röckel (Germany), R.M. Filmer (England) , P.L. van Pel and H. Dekker (both the Netherlands).

Type Locality. Sultanate of Oman, Masirah Island, Sur/Umm Rasas, 0.1-0.6 m below low tide ,Sta. 91/99, November 1991. leg. R.G. Moolenbeek & H. Dekker.

Description of the Holotype. (figs 1-2). Length 11.0 mm, width 5.9 mm. Shell turbinate, thin, glossy, low biconical. Protoconch paucispiral, 1 1/2 bulbous whorls, partly with an indented sculpture. Teleoconch with 4 whorls. Spire stepped, straight to a little concave, whorls canaliculated with irregular growth lines. Shoulder sharply angulated. Body whorl smooth except lower third which has 11 spiral grooves on the ventral and 7 on the dorsal side.

Aperture slender, somewhat expanding towards the base.

Colour. Spire white with irregular dark brown spots. On the bodywhorl are 8 brown spots which continue below the shoulder and are connected to a broader blackish band. Just below the shoulder a small light band is followed by a somewhat broader blackish band. Middle of bodywhorl with a light band in which are about 5 fine brown spotted spirals. In this light band are many irregularly formed milky white spots. Base blackish with irregular white spots in. Periostracum thin, nearly transparent, more prominent on the shoulder forming fine fringes.

Operculum horny, orange-brown, measurements 2.8 x 0.9 mm. Animal not studied alive. After its preservation in alcohol it was blackish, eye stalks white with the eye black. Proboscis with a white tip.

Variability. There is little variation in shape of the shells. However, the colour pattern is most variable (figs 3-6). Especially juvenile specimens can be completely yellowish to orange (fig. 6) with only dark brown spots on the spire. Larger specimens have grey to nearly black colour patterns. About 70% of the studied material consists of specimens with the black colour pattern, but the larger specimens are more greyish. The pattern is very irregular, although in general a lighter mid-body band is present. Fine spiral bands of brown spots can cover the entire body whorl.The largest paratype has a length of 12.6 mm, width 7.0 mm.

Other Material Studied. One shell at Umm Rasas, Sta. 91/99; Nine shells at Ras Abu Zabil, Rounders Bay, 6 m SCUBA, Sta. 91/123, leg. Gary Keat (RAFO). Two shells were found on the west coast of Masirah Island, Valley of the Moon beach, Sta. 91/93; Another two living specimens were collected on Al Hallaniyah (Sta. 91/60), which have a more pronounced sculpture on the protoconch. To find out whether these Al Hallaniyah specimens are conspecific more material and further research is needed. All material collected in November 1991, leg. R.G. Moolenbeek & H. Dekker.

Etymology. *Conus boschorum* is named after Donald and Eloise Bosch, to express our respect for all the activities they have initiated to stimulate malacological research in Oman.

Discussion. Due to its small size, this new species could easily be considered a juvenile of a larger species. Juveniles of *Conus acuminatus* Hwass, 1792 , with a more slender outline, have less canaliculated whorls with one or two, sometimes vague, spirals on it. Also, that species has never been recorded

from Oman. *Conus boschorum* n.sp. lives sympatrically with *C. ardisiaceus* Kiener, 1845, *C boschi* Clover, 1972 and *C. biraghii omanensis* n.ssp. Of these three taxa, only juvenile specimens of *C. ardisiaceus* show resemblance but differs in having spiral grooves on the spire whorls (figs 7-8). Also its shape is more bulbous and it grows larger. In shape and size *C. rutilis* Menke, 1843 from southwest Australia shows similarities. However, its protoconch is more nipple like and the spire is slightly coronated. *C. klemae* Cotton, 1953 from western Australia has a more or less similar outline but has spiral grooves on the spire. Also that species grows much larger.

We have two live collected shells from Al Hallaniyah [=Kuria Muria Island], which might be *C. boschorum* n.sp. However there are slight differences in colourpattern and protoconch structure. Additional material is needed for comparison.

Conus biraghii (G. Raybaudi, 1992) Figs 9-10

This small species was recently described as *Leptoconus (Thoraconus) biraghii* from Somalia. The description was based on a rather monomorph sample, and details on the sculpture of the protoconch were not available. We could study one of the paratypes of *C. biraghii* (figs 9-10) present in the collection of D. Röckel (Germany).

From Masirah Island we have specimens of a small *Conus* species, which has a number of characters in common with *C. biraghii* . Our comparison leads to the conclusion that a subspecific status for the Masirah material is justified.

The shell characters of *C. biraghii* do not assign it to *Leptoconus* , which is based on type species *C. amadis* Gmelin, 1791. The latter is a large species with different size, shape, sculpture and pattern. The same can be applied to *C. exiguus* Lamarck, 1810, type species of *Thoraconus* Da Motta, 1991.

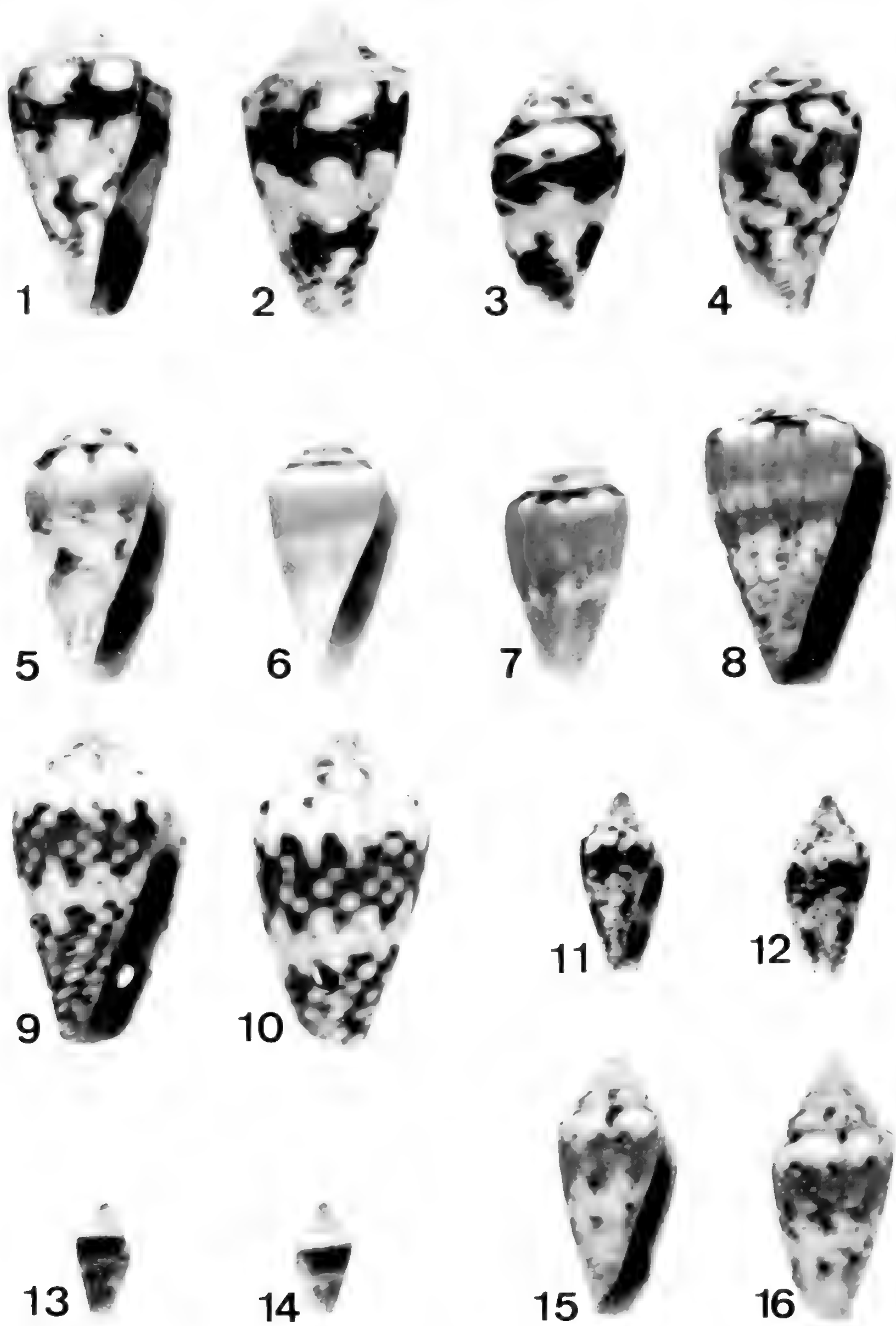
We are of the opinion that the generic classification of the Conidae by DA MOTTA (1991) is premature. The 30 new subgenera he described, will create more confusion rather than being a serious attemp to classify the hundreds of (sub)species in this family. The taxonomy of the Conidae is still far from being settled. This is due to the large number of species (about 600 recent) and the growing number of species [names] every year. Also variability, abundance of (sub)specific names (far over 2000 fossil and recent), homonymy, synonymy , unknown distribution patterns and incorrect localities need more research. Therefore we prefer to use the genus *Conus*.

Conus biraghii omanensis n.ssp. Figs. 11-16, 18

Type Material. Holotype (ZMA Moll. 3.92.003) and 110 paratypes, partly preserved in alcohol (ZMA Moll. 3.92.004). Paratypes will be distributed to the Oman Natural History Museum (Muscat), the National Museum of New Zealand (Wellington) and to the private collections of Dr. D.T. Bosch,Dr. D. Röckel, P.L. van Pel, R.M. Filmer and H. Dekker.

Type Locality. Sultanate of Oman, Masirah Island, Sur /Umm Rasas, 0.1-0.6 m below low tide, Sta. 91/99. November 1991. leg. R.G. Moolenbeek & H. Dekker.

Description of the Holotype (Figs. 6-7). Length 7.7 mm, width 3.6 mm. Shell small, biconic, slender, rather solid. Protoconch of 1 1/2 whorls. Initial part mainly white with brown sutures, remaining part brown with minute opisthocline axial rims (folds). Teleoconch consisting of 4 1/2 whorls. First teleoconch whorl with one strong spiral groove, gradually a 2nd and 3rd appear. Whorls with microscopic growth lines.

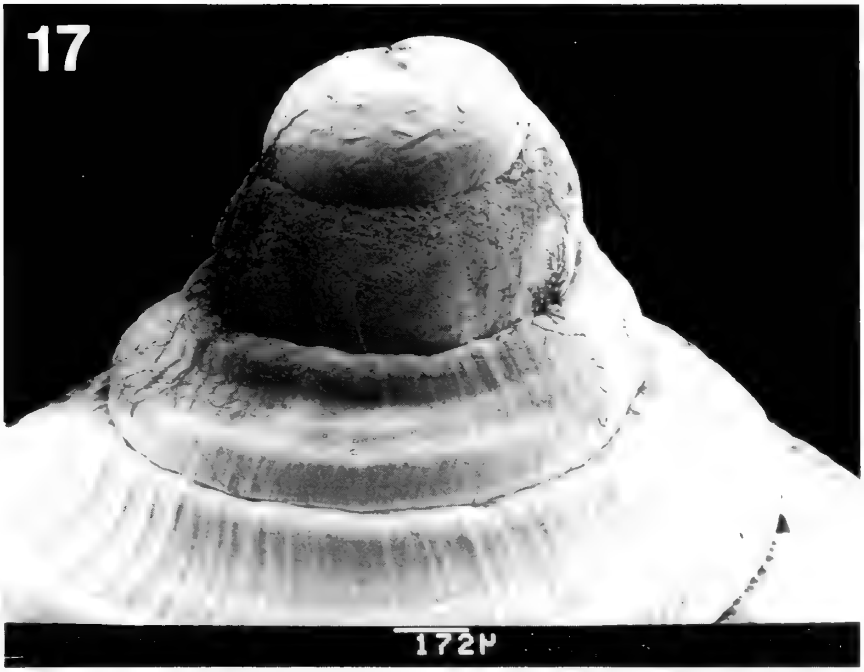


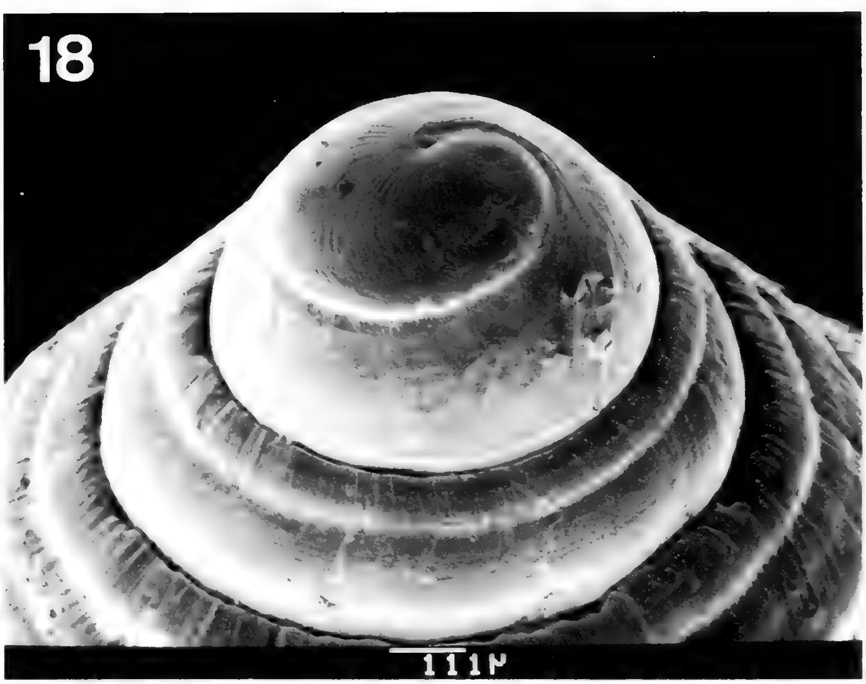
Figs 1-6. *Conus boschorum* n.sp. , Oman, Masirah Island, Sur. 1-2. holotype, length 11.0 mm. 3-6. paratypes, variability in colour pattern, lengths resp.10.8 mm, 11.6 mm, 12.1 mm, 11.0 mm.

Figs. 7-8. *Conus ardisiaceus* Kiener, Oman, Masirah Island, Sur. Length resp. 10.7 mm and 13.1 mm.

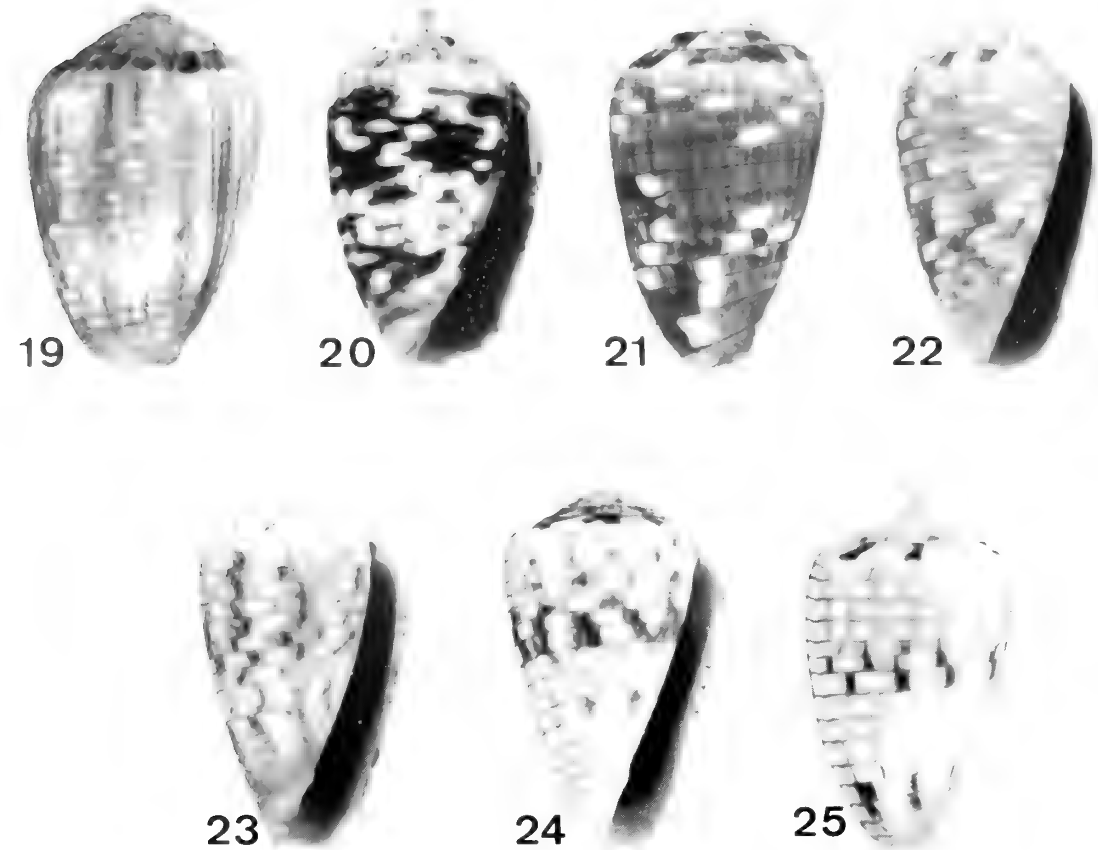
Figs. 9-10. *Conus biraghii* (G.Raybaudi), Somalia, Obja, paratype, length 10.7 mm (coll. D. Röckel).

Figs. 11-16. *Conus biraghii omanensis* n.ssp., Oman, Masirah Island, Sur. 11-12. holotype, length 7.7 mm. 13-14. juvenile paratype, lacking spiral colour pattern, length 4.2 mm, 15-16. paratype, length 10.9 mm.





Figs. 17-18. SEM pictures of protoconchs, Oman, Masirah Islands, Sur. 17. *Conus boschorum* n.sp. 18. *Conus biraghii omanensis* n.ssp.



Figs. 19-25. *Conus melvilli* Sowerby III. 19. holotype of *Conus pusio* Sowerby I and *Conus melvilli* Sowerby III, length 18.8 mm (National Museum Wales, Cardiff, U.K.). 20-25. variation in colourpattern of *Conus melvilli* , Oman, Masirah Island, leg.D.T. Bosch (coll. ZMA), length resp. 29.3 mm, 23.0 mm, 25.8 mm, 20.8 mm, 19.1 mm and 18.0 mm.

Body whorl smooth, with a groove just below the shoulder, which due to the extruded spire, is visible on earlier whorls too. Base dorsally with 7-8 spiral grooves , ventrally a few more. Colour white with greyish upper band. In this band about five spiral white/brown lines. Nearly at the base a 2nd greyish band with 3 spiral lines in it. In between these bands a white area with two or three brown/milky white spotted spiral lines.

Variability. This species shows little variation in shape and colour pattern. Juvenile specimens may have the upper part of the body whorl more or less uniform brown. In a few cases the shells may have more pronounced axial coronation.

Other Material Studied. Two dead collected shells from Maghilah (Sta. 91/94) on the west coast of Masirah Island; one specimen 4 km S.of Ra's Qudufah, Sta. 91/86; Four specimens at Ra's al Ya, Sta. 91/105; one beached specimen at BERS camp, Sta. 91/95; one specimens at the Valley of the Moon beach, Sta. 91/93; Five specimens at Ra's Zafarnat, Turtle rock,7-8 m SCUBA, Sta. 91/121, leg. Gary Keat (RAFO); On Al Hallaniyah [Kuria Muria Islands, Sta. 91/60] we collected seven juvenile specimens (partly live collected) which seem to have more pronounced spiral sculpture on spire and body whorl.In the province Dhofar, we collected 4 dead specimens at Dar Marbat, Sta. 91/71. All material November 1991, leg. R.G. Moolenbeek & H. Dekker.

Etymology. This subspecies is named after the Sultanate of Oman.

Discussion. The only species which shows some similarities in design is the recently described *Leptoconus (Thoraconus) biraghii* G. Raybaudi, 1992 from Somalia. *Conus biraghii omanensis* differs from the nominate species by having less pronounced coronations and in being more obconic. The spirals on the teleoconch are lacking on *C. b.biraghii*. *Conus papalis* Weinkauff, 1875 from the Philippines of which several authors doubt the generic status, has more pronounced coronation and strong spiral grooves on the teleoconch. In the Natal Museum (Pietermaritzburg, South Africa) are two unidentified specimens from northern Mozambique, Conducia Bay (leg. K.J. Grosch, no. G 9936) which look identical in shape, size and sculpture to the Oman population. Only the colour of the body whorl is brownish. The holotype of *C. traillii* A. Adams, 1855 in the Natural History Museum, London agrees in colour pattern but differs in being bullet-shaped, completely smooth on the whorls, having deep sutures and lacking a groove below the shoulder.

As long as no detailed description is provided for the population from Somalia we prefer to maintain a subspecific status for the Oman population.

Conus melvilli Sowerby III, 1879 and *Conus boschi* Clover, 1972 Figs 19-25

COOMANS & MOOLENBEEK (1982) published on the identity of *Conus pusio* Sowerby, I, 1834 (Fig. 19) and *C. melvilli* Sowerby III, 1879. They concluded that both nominal species were based on the same type specimen and thus are objective synonyms. At that time we concluded that *Conus boschi* Clover, 1972 was a distinct species. However, after having studied more material of *C. boschi* (figs 20-25) recently collected and kindly donated by Donald Bosch, it shows that *C. boschi* on Masirah Island has a large variation in colour pattern. This variation includes the pattern of *C. melvilli* which therefore is the first available name for this taxon. *C. boschi* becomes a junior synonym.

Acknowledgements. We express our gratitude to Donald Bosch, who brought to our attention the interesting malacofauna of Oman and invited us to participate in the Oman

expedition initiated by him. Thanks are due to the staff of the BERS station on Masirah Island for hospitality during our stay.Gary Keat and one of his collegues (RAFO base) were so kind to collect some samples from deeper water using SCUBA. Peter and Una Dance, Christine and Walter Hägstrom, Donald and Eloise Bosch and Henk Dekker were companions during our collecting activities and always willing to assist us. KLM Oman (Mrs J.W. Creutzberg and J. Simpson) kindly arranged a courtesy air ticket from Amsterdam to Seeb. D. Röckel sent material in loan. Mike Filmer corrected the English text. Mr. L.A. van der Laan (ZMA, University of Amsterdam) made the photographs, the SEM pictures were made by the first author at the Laboratorium voor Elektronenmikroskopie (University of Amsterdam).

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Volvarina pontesi, a new bathyal marginellid (Mollusca, Gastropoda) from off Brazil

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KEY-WORDS: Marginellidae, South Atlantic, Bathyal, *Volvarina*, new species.

ABSTRACT. *Volvarina pontesi* is described from the bathyal zone off southeastern and southern Brazil. The new taxon differs from other congeneric species by its large size and unusually elongated spire.

INTRODUCTION

An unknown marginellid was obtained at bathyal depths off southern Brazil during the GEOMAR IV (Marine Geology IV) cruise performed by N. Oc. *Almirante Saldanha* of the "Diretoria de Hidrografia e Navegação" (DHN) of the Brazilian navy in 1972. Additional material of the same species was collected on the slope of southern and southeastern Brazil by the RV *Atlântico Sul* of "Fundação Universidade do Rio Grande" (FURG) in 1987, and by the RV *Marion Dufresne* during the French-Brazilian MD55 cruise realized by "Terres Australes et Antarctiques Françaises" (TAAF) in 1987. The small number of live-collected specimens hampered further anatomical studies, but shell and radular morphology allocate the new species in the genus *Volvarina* Hinds, 1844.

RIOS (1985), having in mind future taxonomic work with the present species, introduced the nomen nudum *Ledavolvarina* on the third cover of his 1985 book. Acronyms used throught the text are: MNHN, Muséum National d'Histoire Naturelle, Paris, France; MNRJ, Museu Nacional, Rio de Janeiro, Brazil; MORG, Museu Oceanográfico E. de C. Rios, Rio Grande, Brazil; USNM, National Museum of Natural History, Smithsonian Institution, Washington, USA.

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Family Marginellidae Fleming, 1828
Genus *Volvarina* Hinds, 1844
***Volvarina pontesi* sp.n.**
(Figures 1-8)

Shell (Figures 1-6) solid, cylindrical-fusiform, tapering at base, imperforate, reaching 15.1 mm length and 4.3 mm width, smooth, glossy. Protoconch round, white, with 1.5 whorls, 0.9 mm diameter. Transition from protoconch to teleoconch inconspicuous. Spire high, acute, apical angle about 20°. Suture distinct, not canaliculated, covered by transparent enamel. Teleoconch with four or five straight whorls. Aperture elongate (length/width about 7), about 0.5 of shell length, narrower adapically. Outer lip straight or slightly concave. Columella with 4 small, abapical plicae, all of same size. Anterior canal shallow, wide. Outer lip straight, smooth internally. Parietal region smooth. Periostracum absent.

Radula (Figures 7 & 8) rachiglossate, formula 0-R-0, with about 28 rows and 0.17-0.20 mm length. Rachidian tooth multicuspid, asymmetrical, with 19-23 cusps. Four to six large cusps unevenly distributed among small cusps.

Holotype. MORG 17889, 15.1 mm length, 4.3 mm width, N.Oc. *Almirante Saldanha* GEOMAR IV cruise, station 2820, Van Veen grab.

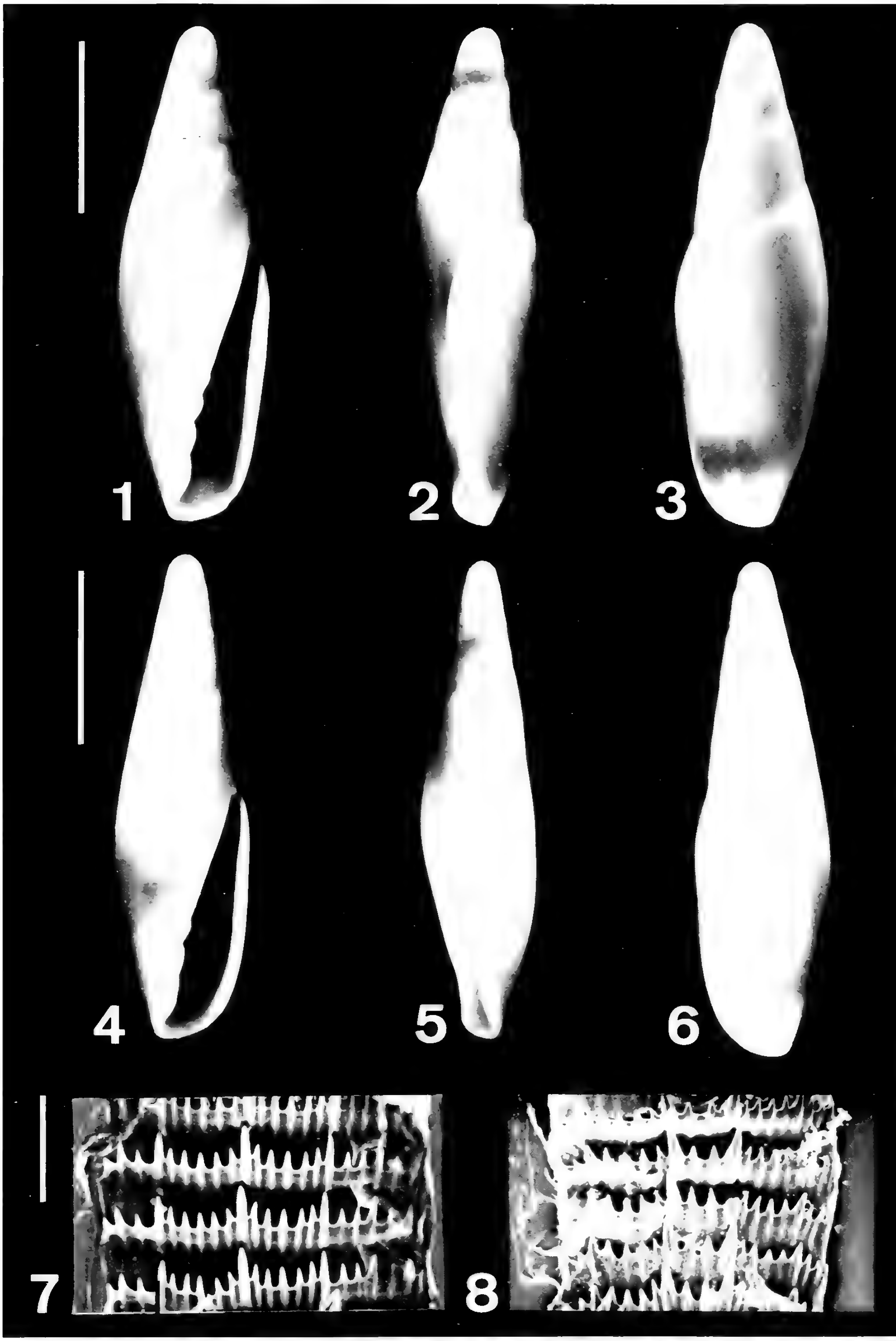
Type Locality. Off Itajaí, Santa Catarina State, Brazil (27°00' S - 46°10' W), 1140 m depth, sandy mud bottom.

Paratypes. Paratype 1, MNRJ 4850, length 13.2 mm; paratype 2, USNM 749862, length 13.3 mm; both from type locality; paratype 3, MORG 24983, off Torres, Rio Grande do Sul State, RV *Atlântico Sul*, 200 m depth, length 13.6 mm; paratypes 4-8, MORG 26075, off Rio de Janeiro State, Brazil (23°42' S - 42°07' W), Bouchet, Leal & Métivier 05/1987, RV *Marion-Dufresne* MD55 cruise, station CB-104, 430-450 m depth, Blake trawl, muddy bottom, lengths 13.5-14.0 mm; paratypes 9-12, MNHN, unnumbered: paratype 9, length 14.4 mm; paratype 10, length 13.5 mm; paratype 11, length 14.1 mm; paratype 12, length 13.5 mm; last four from off Rio de Janeiro State, Brazil (23°47' S - 42°10' W), Bouchet, Leal & Métivier 05/1987, RV *Marion-Dufresne* MD55 cruise, station CB-105, 610 m depth, Blake trawl, muddy bottom.

Etymology. Named after fisherman Leopoldino R. Pontes from Rio Grande, Brazil, who provided material to the Museu Oceanográfico (MORG) for three decades. Mr. Pontes collected extensively mollusks and shells aboard the fishing vessels *Pescal 2*, *Mestre Gerônimo* and *Akaroa*.

Remarks. General shell morphology and radula allocate the new species in the genus *Volvarina* (COAN, 1965; COAN & ROTH, 1976; ROTH, 1978). The comb-like radular tooth is somewhat similar to those in *Volvarina bilineata* (Krauss, 1848) (COOVERT & COOVERT, 1987) and *Volvarina philippinarum* (Redfield, 1848)

Figures 1-8 (opposite). *Volvarina pontesi* sp.n.;
1-3. Holotype, MORG 17889, 13.8 mm length, 4.3 mm width;
4-6. Paratype 9, MNHN, 14.4 mm length, 4.0 mm width;
7-8. Radula. Scale bars: Figures 1-6 = 5 mm; Figure 7-8 = 0.05 mm.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(COAN, 1965). Future studies in comparative anatomy may, however, indicate that *V. pontesi* belongs in a separate genus.

Volvarina pontesi is promptly distinguishable from most *Volvarina* by its large size, slender shape and rather high spire. The new species is somewhat similar in shell morphology to the Patagonian-Magellanic *Volvarina warrenii* (Marrat, 1876) [= *V. patagonica* (Martens, 1881] and *V. dozei* (Rochebrune & Mabille, 1889), from which it differs by a more elongate shell with relatively longer spire, white protoconch and early teleoconch whorls, which are dark in *V. warrenii* and *V. dozei*, and the absence of a well-delineated, white band in the middle of the body whorl,present in the other two species (CARCELLES, 1946; POWELL, 1951). It somewhat resembles *V. gracilis* C.B. Adams, 1851 (see illustration in CLENCH & TURNER, 1950). However, *V. gracilis* is a much smaller species, reaching around 7 mm in length, whereas adult *V. pontesi* measures about 13 mm. The relationship length of aperture/total length in the new species is about 0.5; the same ratio is about 0.7 in *V. gracilis*.

Acknowledgments.
We are indebted to Philippe BOUCHET of the Muséum National d'Histoire Naturelle, Paris, who provided material collected during the French-Brazilian MD55 cruise of the *Marion-Dufresne*.

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Description of a new species of the genus *Favartia* Jousseaume,1880 (Gastropoda: Muricidae) from the Indian Ocean.

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KEYWORDS: Gastropoda, Muricidae, *Favartia* n.sp., Somalia.

ABSTRACT. *Favartia cecalupoi*,a new muricid species,is described from off Ras Hafun, the Northeastern point of Somalia. Like other recently named species from the same area, *F. cecalupoi* was trawled by fishing boats operating in waters off the Horn of Africa.

INTRODUCTION

In the recent years several new deep water species have been discovered in the northwestern part of the Indian Ocean; many of them are muricids: *Hexaplex bozzadamii* (Franchi,1990), *Poirieria hemmenorum* Houart & Mühlhäusser,1990, *Chicoreus elisae* and *Muricopsis chiarae* Bozzetti,1991. Most of these species have been found by trawlers off the Somalian coast, in the area between Cape Guardafui and Ras Hafun. These seashells, together with the other sea products, are discharged at the Port of Jibuti, and then, thanks to the cooperation of some local traders, they reach the European countries. A great number of species coming from that area can be found along the southern coast of East Africa as well : the Mozambique Channel and Natal; their lack off Kenya and Tanzania is probably due to the non exploitation of sea resources in this intermediate area.

DESCRIPTION

Shell medium sized for the genus, fusiform. Spire high consisting of two smooth bulbous nuclear whorls and up to five convex, postnuclear whorls, separated by an impressed suture. Aperture ovate to subcircular, outer lip sharp, protruding, weakly crenulate, the crenulations reflecting the surface sculpture, with a strong fimbriate varix. Inner side of the outer lip lyrate; columellar lip adherent above and detached below, with a smooth internal surface, siphonal canal short, open and dorsally recurved. Axial sculpture consisting of widely spaced varices in number: five to seven on the body whorl and seven or eight on the upper whorls. Weak axial ridges on the intervarical area. Spiral sculpture consisting of scabrous cords, two on the upper whorls and five on the body whorl, the first one on the shoulder; on the varices the cords are stronger and expanding in short rounded spines. Numerous weak ridges between adjacent cords, sometime a minor single cord present. A variable size gap in the spiral sculpture is followed on the siphonal canal by two cords.

Shell colour salmon to orange-red, lightest on the varices and columellar callus; upper side of apertural varix whithish, protoconch brown-pinky, inside of the aperture salmon coloured.

DISCUSSION

Favartia cecalupoi is related to the South African *Favartia natalensis*, (E. A. Smith,1906) but it differs from this one in the more dense axial sculpture, weaker spiral cords and in the colour: *Favartia natalensis* is white with some black stained lines present inside of the aperture, corresponding to external cords. Another similar species is *Favartia minirosea* (Abbott,1954) which seems to be endemic to the Gulf of Mexico,

where it is to be found in moderate deep waters (from 50 to 100 meters). The main differences are in the sculpture and size : *Favartia minirosea* bears stronger and more denser spiral cords and its average length is 6/7 mm.

TYPE LOCALITY

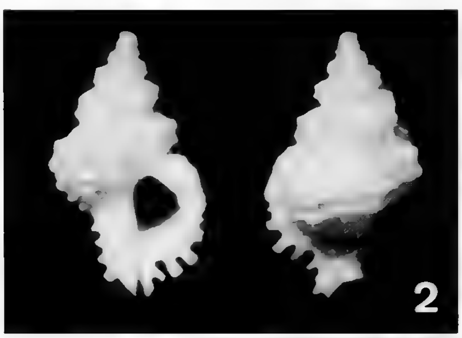
Off Ras Hafun, 150 Km south of Cape Guardafui. Taken By trawlers in sandy bottoms at 200-250 m depth.

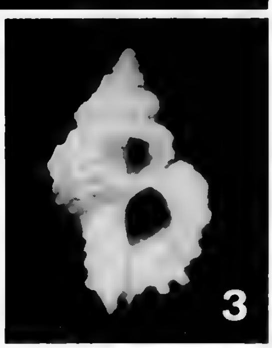
TYPE MATERIAL

Holotype IRSNB IG 27882/455, 14 mm, 1 paratype IRSNB IG 27882, 10.5 mm, 1 paratype Natal Museum, K8086/T838, 11 mm, 1 paratype MNHN, 10.7 mm, 1 paratype coll. R. Houart, Landen (Ezemaal) Belgium, 9.6 mm, 4 paratypes coll. Bozzetti, 10.6 mm, 8.3 mm, 7.4 mm, 9.2 mm, 1 paratype coll. A. Cecalupo, Milan, Italy, 12.2 mm, 1 paratype coll. F. Franchi, Piacenza, Italy, 10.3 mm.

ETYMOLOGY.

I dedicate this species to my friend Alberto CECALUPO, grateful for his invaluable help.





Figs. 1-3: *Favartia cecalupoi*, n. sp.

1. Holotype, IRSNB IG 27882/455, 14 mm.
2. Paratype, IRSNB IG 27882, 10.5 mm.
3. Paratype MNHN, 10.7 mm.

A remarkable new species of *Poirieria* (*Flexopteron*) (Gastropoda: Muricidae) from the Philippine Islands.

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KEY-WORDS: Gastropoda, Muricidae, Muricinae, Philippine Islands, new species.

ABSTRACT. *Poirieria* (*Flexopteron*) *poppei* is described from 2 specimens dredged off Balut Island, in the Philippines. It is the second known Recent species of *Flexopteron*, and is compared with *P. (F.) philippinensis* (Shuto, 1969) and *P. (F.) primanova* Houart, 1985.

RESUME. *Poirieria (Flexopteron) poppei* est décrit à partir de deux individus récoltés au large de l'île de Balut, dans les Iles Philippines. Il s'agit de la deuxième espèce non fossile de *Flexopteron*. Elle est comparée à *P. (F.) philippinensis* (Shuto, 1969) et *P. (F.) primanova* Houart, 1985.

INTRODUCTION.

The subgenus *Flexopteron* was named by SHUTO (1969: 111) in the Coralliophilidae, for a fossil shell from the Philippines. HOUART (1985: 166, figs 3-3d) described the first known Recent species and illustrated the radula. As stated in VOKES (1992), the radula is close to those of *Poirieria s.s.* or to trophonine genera such as *Boreotrophon* and *Nipponotrophon*, although with a narrower rachidian tooth, bearing comparatively longer lateral denticles. The classification of *Flexopteron* as a subgenus of *Poirieria* is therefore subject to discussion. More material and more intensive researchs are needed before any decision can be taken, and as suggested in VOKES (1992), for now it is better to leave these taxa in their accustomed place. Nevertheless, the discovery of a living specimen of *Flexopteron* in the Philippines is very interesting, and certainly the most exciting news for the moment.

Poirieria (Flexopteron) poppei n.sp.

Figs 1-6

MATERIAL STUDIED.

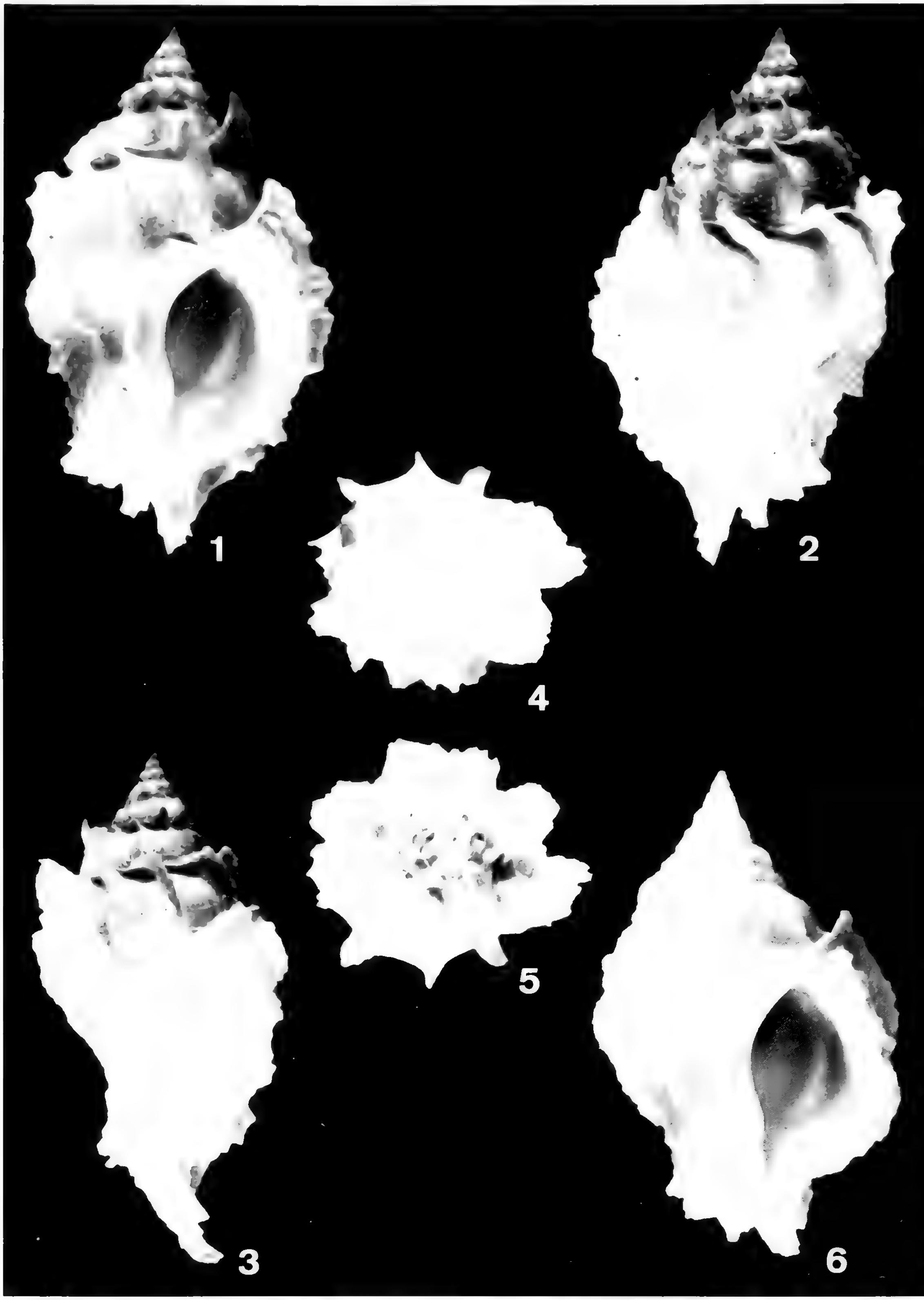
Holotype 52 X 29.5 mm, MNHN and 1 paratype 47 X 29 mm, coll. G.T. Poppe.

TYPE LOCALITY.

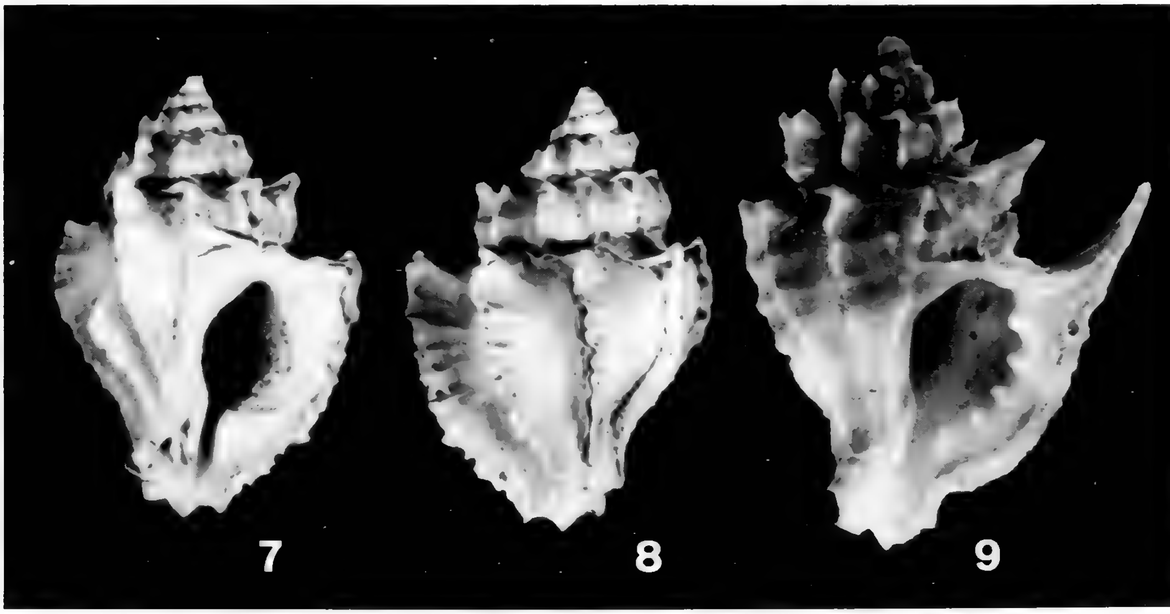
Mindanao, Balut Island, Philippine Islands, from tangle net, exact depth unknown, approximately 400-450 m.

DESCRIPTION.

Shell large, up to 52 mm in length (holotype), heavy, lamellate, up to about 7 teleoconch whorls. Spire high, acute. Protoconch eroded, remaining parts suggesting it to be paucipiral, with 1 1/4 to 1 1/2 whorls. Teleoconch whorls broad, rounded. Suture obscured by axial lamellae of following whorl. Teleoconch whorls ornamented with sharp, spineless,



Figs 1-5. *Poirieria (Flexopteron) poppei* n.sp., holotype MNHN, 52 mm X 29.5 mm.
Fig. 6. *P. (F.) poppei* n.sp., paratype coll. G.T. Poppe, 47 mm X 29 mm.



Figs 7-8. *P. (F.) philippinensis* (Shuto, 1969), holotype GK.L 6943, 17 mm X 11.9 mm.

Fig. 9. *P. (F.) primanova* Houart, 1985, holotype MNHN, 14.7 mm X 11.4 mm.

raised lamellae, 10 on first teleoconch whorl, 8 on second, 9 or 10 from third to fifth, 8 or 9 on sixth whorl, and 8 on last teleoconch whorl. Spiral sculpture consisting of numerous, low, rounded cords, more apparent on the abapertural face of the axial lamellae. Last teleoconch whorl with 23-25 spiral cords. Aperture ovate, comparatively small. Columellar lip smooth, completely adherent. Anal notch shallow, broad. Outer lip erect, finely and weakly crenulate, smooth within. Siphonal canal comparatively short, smooth, broad, weakly abaperturally bent, open. Previous canals fused, forming open, narrow umbilicus. Colour whitish to light orange or light brown, lamellae of last teleoconch whorl slightly darker coloured, aperture glossy white. Operculum and radula unknown.

REMARKS.

Poirieria (Flexopteron) poppei differs from *P. (F.) philippinensis* (Shuto, 1969) in having a higher spire, more adapically curved axial lamellae, a shorter siphonal canal, more rounded teleoconch whorls (not shouldered as in *P. philippinensis*), and mostly in having 23-25 rounded spiral cords on the last teleoconch whorl, for only 10 in *P.philippinensis*. *P. poppei* differs from *P. primanova* Houart, 1985 in the same way; furthermore, *P. primanova* has only 6 spiral cords and numerous fine threads on the last teleoconch whorl.

ETYMOLOGY.

Named for Mr Guido T. Poppe, who kindly provided the studied material.

Acknowledgements.

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Description of a new species and a new subspecies of *Conus* (Mollusca : Prosobranchia : Conidae) from the Canary Islands.

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KEY WORDS: Gastropoda, Conidae, new species and new subspecies, Canary Islands.

ABSTRACT. *Conus guanche* is described from Tenerife, Islas Canarias (Spain). The new species is compared with several species from western Africa, especially with *Conus guinaicus* Hwass in Bruguière, 1792 and *Conus adansonii* Lamarck, 1810. *Conus guanche nitens* is described from Lanzarote (Canary Islands).

RESUME. *Conus guanche* est décrit de Ténérife, Iles Canaries (Espagne). La nouvelle espèce est comparée avec plusieurs espèces de l'Ouest Africain, en particulier avec *Conus guinaicus* Hwass in Bruguière, 1792 et *Conus adansonii* Lamarck, 1810. *Conus guanche nitens* est décrit de Lanzarote (Canaries).

INTRODUCTION.

K. BANDEL and E. WILS (1977) published an interesting article entitled "On *Conus mediterraneus* and *Conus guinaicus*". In this article, the authors presented several populations from Lanzarote, Fuerteventura and Tenerife, as belonging to the species *Conus guinaicus*, and separated convincingly these populations from *C. mediterraneus* Hwass, while they pointed out the reasons why they prefer the name *C. mediterraneus* to *C. ventricolus* (Röding).

In 1990, I collected over 120 specimens of a Canarian species of *Conus*, and compared them with *C. guinaicus* and several other related species. My conclusion was that these populations neither belong to *C. guinaicus*, nor to any other known species.

Conus guanche, spec. nov.
(Figs. 3-4-5)

DESCRIPTION.

Shell moderately elongate, slightly ventricose. Colouration of the background bluish gray. Body whorl smooth and moderately glossy.

Protoconch : like the majority of the *Conus* of a group generally classified in the subgenus *Lautoconus* Monterosato, 1923, the protoconch is nearly always eroded. From the best specimens, it may be deduced a protoconch of intermediate multispiral type.

Spire : postnuclear whorls are from 8 to 9, depending on shell maturity. Spire whorls convex to swollen, this convexity becoming weaker in mature specimens. Suture well marked, underlined with dark-brown, very fine spiral striae, without marked grooves.

Numerous and close radial striae, slightly curved towards the left.

Shoulder : rounded with a very weak subangulation.

Body whorl : sides slightly ventricose tending to become straight towards the anterior half which is slightly concave in juveniles. The basal quarter is covered with 9 to 11 small and close, sometimes duplicated ridges.

Aperture : The lip is sharp, rather thin on its external edge. It is bordered with a narrow (1 to 2 mm) yellowish inner strip. The inside shows a dark reddish or violet-brown dash, becoming paler and tending to bluish-gray towards the back. This brown zone, which covers the inside from the suture to the base is interrupted by two yellowish small spiral bands, localized near the shoulder and the anterior 2/5 of the aperture.

Pattern : The pattern is remarkably constant, showing a very restricted variability. Spire : the background is covered with more or less close radially vermiculate brown dashes. The body whorl shows 2 or 3 wide yellowish-ochre spiral bands, and is ornamented with zigzaging, sometimes more or less triangular, chestnut to blackish-brown blotches, which enlarge towards the wide yellowish bands. Some rather rare specimens show a paler small band around the anterior 2/5.

Periostracum : pale greenish-brown, rather thick but translucent. The shell is generally covered with large and thick chalky concretions.

COLOUR OF THE ANIMAL :

The foot is dark gray. Proboscis and siphon are black. The sole of the foot, pale to pinkish gray.

MORPHOMETRIC INDICATIONS : (see tables II to III & graphs I to III).

Average size : 27.55 mm.

Average height of the shell/width ratio : 1.81.

Average weight/height of the shell ratio : 0.103 gr/mm.

Average apical angle (in degrees) : 89°.77.

MATERIAL EXAMINED

128 live taken specimens from 17,7 to 38,3 mm, 26 specimens of which, including holotype and paratypes, were retained for the morphometric study.

ORIGINAL MATERIAL

Holotype :	34.0 x 18.2 mm
Paratype n° 1 :	26.6 x 14.8 mm
Paratype n° 2 :	29.8 x 15.8 mm
Paratype n° 3 :	31.0 x 17.9 mm
Paratype n° 4 :	26.2 x 14.3 mm

Paratypes n° 5 to 10 from 27.9 to 38.5 mm.

Holotype and paratype n° 1 are deposited in the Museum National d'Histoire Naturelle (M.N.H.N.) in Paris. Paratype n° 2 Museo Insular de Ciencias Naturales, Santa Cruz de Tenerife, Canarias. Paratype n° 3 Museum d'Histoire Naturelle in Geneva n° MNHG 993/101, n° 4 Zoölogisch Museum in Amsterdam, n° ZMA Moll.3.93.011. Paratypes n° 5 to 10 in authors collection.

TYPE LOCALITY

Punta Blanca, about 8 km southern of Los Gigantes, west coast of Tenerife, Canary Islands, between rocks at 0,30 to 2,50 meters depth.

DISTRIBUTION

Conus guanche seems to be endemic to the Canary Islands. A population which occurs in Fuerteventura, Lanzarote, Graciosa and Lobos presents a some different taxonomy and is hereunder described as a provisional subspecies. A third population occuring in western Gran Canaria (fig. 9) shows some taxonomical particularities, but needs more researches about its true identity. From extreme Southern Spain (southern of Cadix) to the Mauretania occurs another uncertain population which may be related to *C. guanche*, but its badly known taxonomy, ecology and ethology do not allow any serious conclusion for the moment. Its determination on a specific level and its real relation with *C. guinaicus* need further studies.

ECOLOGY and ETHOLOGY

C. guanche manifests diurnal activity. This activity is submitted to the tide movements, and is practically inexistant during falling or low tide. With the rising tide, the animals begin to leave their refuges (rock crevices) and to get to the top of rocks which are covered of sea grass. They are vermivorous (polychaetes). The Canarian coasts (volcanic substratum are subjected to the assaults of occasional rough sea, which explains the rather bad shell conditions of a shallow waters species.

ETYMOLOGY

Conus guanche is named in memory of the GUANCHES (adj. guanche), the first known inhabitants of the Canarias, who had elaborated a very original civilization before destroyed during more than hundred years (XV th. and XVI th. centuries) by the Spanish "Conquistadores".

DISCUSSION

1) The new species should be compared with some related species. In my introduction I cited BANDEL & WILS 's article. The authors distinguish, at a specific level, *C. guanche* (misidentified as *C. guinaicus* Hwass in Bruguière, 1792) from *C. mediterraneus* Hwass in B., 1792 (= *C. ventricosus* Gmelin, 1791 ?) on the basis of convincing arguments such as very significative differences of the egg capsules, radular teeth, a.s.o. I totally agree with their conclusion.

2) COOMANS, MOOLENBEEK and WILS (1985) misidentified this species as *C. desidiosus* Adams, 1854 (1985 : 165, 191 fig. 634). After examination of the holotype, we conclude that *C. desidiosus* belongs to the *C. mediterraneus* group, and is identical to the specimens of a population from Lampedusa Island (Italy), between Eastern Tunisia and Malta.

3) *C. xicoi* Röckel, 1987 shows some remarkable resemblences in its patterns. However its height/width ratio (between 1.6 and 1,7) is significatively lower than the one of *C. guanche* (from 1.69 to 1.93), which indicates a stockier shell. The shoulder is flatter, as well as the spire whorls, and subangulated. The spiral grooves on the 4-5 first postnuclear whorls (RÖCKEL, 1987 : 45) are absent in *C. guanche*, and the animal is pinkish. In addition, *C. xicoi*, endemic to Angola is a tropical (warm waters) species, whereas *C. guanche* is a temperate waters one (Cold Canarian Stream).

4) In many places, *C. guinaicus* is sympatric with *C. guanche* (personal observations in Los Christianos, Tenerife and La Santa, Lanzarote). The shells of this species are totally identical to those from Senegal (size, shape, colours, pattern, ecology). A single view of the comparison tables will convince that *C. guinaicus* and *C. guanche* must be separated on a specific level.

5) *C. adansonii* Lamarck, 1810 (= *C. hybridus* Kiener, 1845) another species from Senegal, curiously shows closer characters, but can be easily separated on morphological and morphometric data, as it can be observed in the comparison tables and graphs.

6) *C. tamsianus* Dunker, 1853 also shows some similarities, but is described from Annobon Island (off Gabon). Thus it is a tropical (warm) waters *Conus*, here considered as a subspecies of *C. aemulus* Reeve, 1844.

Conus guanche nitens subspec. nov. (figs. 6-7-8)

NOTE

C. guanche nitens presents some morphological, morphometric and ethological differences. It is here described as a subspecies, which does not exclude a further specific status because it is seemingly sympatric with *C. guanche* s.s. in some localities at Lanzarote. This sympatry, which would exclude a subspecific status, as well as a morphometric treatment based on more numerous specimens, need confirmation and further investigations. Only 8 specimens in good conditions were available for the

morphometric examination which pointed out several more or less significative differences.

DESCRIPTION

Its apical angle is less obtuse (mean : 80.25° verso 89.79°). Sides, of the spire generally straight to slightly concave (convexe in *C. guanche s.s.*), body whorl less ventricose or nearly straight. The spire is heigher (H/S ratio: 3.94 verso 4.57 - Relative Spire Height : 0.26 verso 0.22). For other morphometric indications, see tables and graphs.

The pattern is quite different : background pale whitish to slightly yellowish gray, covered with wider tawny to nearly orange dashes, less numerous than in *C. guanche s.s.* and often overlined with darker tawnish punctate lines. The yellowish strip observed inside of the aperture of this last here is totally white, and the inner blotch is reddish-brown.

MATERIAL EXAMINED

14 live taken specimens from 18,8 to 33,1 mm, 8 specimens of which including holotype and paratypes n° 1 and 2 were retained for the morphometric study.

TYPE MATERIAL

Holotype	26.2 x 13.2 mm
Paratype n° 1	30.5 x 15 mm
Paratype n° 2	22.2 x 12.5 mm

Holotype and paratype n° 1 are deposited in the Museum National d'Histoire Naturelle in Paris. Paratype n° 2 in the author's collection.

TYPE LOCALITY

Islote de los Ingleses, Arrecife, Lanzarote, Canary Islands, in 0.50 to 1.20 m. depth, by rising tide.

DISTRIBUTION

C. guanche nitens is known from south-western Fuerteventura, from Lobos Isl., Lanzarote and Graciosa. The populations from Fuerteventura and Lobos are somewhat paler, sometimes without brownish dashes.

ECOLOGY-ETHOLOGY

C.guanche nitens has the same activity and feeding customs, but its habitual refuge is in sandy bottom, at the foot of the volcanic rocks.

ETYMOLOGY

nitens is a Latin adjective (= bright) (Cicero).

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TABLE I : MORPHOLOGICAL COMPARISONS

CHARACTERS	*Conus guinaicus*	*Conus adansonii*	*Conus guanche*	*Conus guanche nitens*
SPIRE **shape**	straight to slightly convex in adults	nearly straight.	straight to convex.	straight to slightly concave.
n.of postnuclear whorls	7 to 8.7 (mean: 7.8)	7.7 to 9.2 (mean: 8.8)	8 to 9 (mean: 8.6)	7.6 to 8.8 (mean: 8.4)
SPIRE WHORLS **profile**	slightly convex, except the last whorl which is somewhat depressed	slightly convex, last whorl flat in adult shells	convex to bulging, last whorl nearly flat in adult shells	bulging, also as the last whorl, even in adult shells
spiral sculptures	4 to 7 small spiral grooves	2 to 4 spiral grooves	no grooves, replaced by fine and close spiral striae	no grooves, replaced by fine and close spiral striae
radial sculptures	faint, close and curved radial striae	faint, close and curved radial striae	tenuous and very close curved radial striae	ido -
suture	somewhat irregular	linear	linear	linear
SHOULDER	rounded whit a very weak subangulation	rounded, slightly subangulated	rounded	rounded
BODY WHORL **surface**	smooth to slightly glossy	smooth to slightly glossy	smooth to slightly glossy	smooth to slightly glossy
profile	strongly curved to ventricose	moderately curved and elongate	moderately ventricose, nearly straight in the anterior half	nearly straight below the shoulder curve
sculptures	very faint spiral striae, fine and close axial ones	fine and close axial striae	very fine spiral striae, fine and close axial striae	ido -
basal sculptures	10 to 12 little marked and oblique basal ridges which become nearly invisible in adult specimens, except 4 to 5 ones on the ventral side.	12 to 15 oblique, somewhat granulose basal ridges, often visible only on the ventral side, nearly invisible on the dorsal one.	9 to 11 oblique, often duplicated, more or less flat basal ridges, which remain visible on the dorsal side	ido -

TABLE I : MORPHOLOGICAL COMPARISONS (Continuation)

CHARACTERS	*Conus guinaicus*	*Conus adansonii*	*Conus guanche*	*Conus guanche nitens*
APERTURE width	broad, widening towards the base	moderately wide, only slightly widening tow. base	moderately wide, doing not enlarge towards the base	ido -
inside colours	reddish-brown blotch, becoming pale bluish gray towards the inside. Two whitish small bands below the shoulder and the midbody	violet-brown blotch, becoming whitish-gray towards the inside. A small whitish band below the shoulder, a wider one towards the midbody	dark reddish to violet-brown blotch, becoming bluish-gray towards the inside. Two small whitish bands below the shoulder and the midbody	reddish- brown blotch becoming whitish towards the inside. A small whitish band below the shoulder, a wider one below the midbody
lip	strong but sharp	strong but sharp	rather thin and sharp	thin and very sharp
inside strip of the lip	pinkish to yellowish-white	whitish, with brown spots	yellowish	whitish
columellar fold	whitish, strong, straight to somewhat twisted	pale beige, small, nearly straight	beige, strong, bulging and slightly curved	whitish, narrow , bulging and slightly curved
"anal" notch	broad, strongly underlined with deep brown, narrowing and strongly curved towards the shoulder	rather broad, underlined with deep brown, enlarging and curved towards the shoulder	rather broad, tinged whit violaceous brown, little curved, enlarging towards the shoulder	moderately broad, tinged with darker gray, little curved, not enlarging towards the shoulder
COLOUR PATTERN background	whitish to bluish-gray	bluish to greenish gray, whitish band on the midbody	bluish to greenish gray	pale bluish to yellowish gray
spire	speckled with large brownish or tawny, more or less radially arranged dashes	speckled with small blackish scattered, more or less radially arranged dashes	speckled with small brown to tawny dashes	whitish gray with radially flamulated tawny dashes
spire suture	sometimes underlined with a very fine brownish line	bordered with pale pinkish to tawny shades	strongly underlined with dark blackish-brown	strongly underlined with dark brown
body whorl	hightly variable: mostly covered with pale tawny to deep brown dashes, roughly separed by 2 or 3 bands of whitish ones. Some specimens show weak axial flamules	covered with dark brown more or less triangular small dashes, somewhat aligned in spiral lines and axial flamules and separed in two zones by a whitish more orless white spiral band at the midbody	more or less close radially vermiculate or zigzaging brown dashes, of more or less triangular shape. Sometimes a paler small band encircles the midbody.	covered with wider tawny to orange-brown dashes, often overlined with darker tawny punctate lines

TABLE II : MORPHOMETRIC COMPARISONS

		C.guinaicus	*C.adansonii*	*C.guanche*	*C.g.nitens*
H	Minimum	22.3	28.3	18.5	18.8
HEIGHT of the SHELL	Maximum	52.2	48.3	38.3	30.5
	MEAN	39.14	40.03	27.56	23.89
	Standard Deviation	8.89	5.891	5.814	4.416
	Variation Coef.	22.71 %	14.72 %	21.10 %	18.48 %
	Confid.Interval 95%	22.6> <56.9	28.2> <51.8	15.7> <39.2	14.6> < 32.7
LD	Minimum	12.3	14.2	9.6	9.8
LARGEST DIAMETER	Maximum	30	25.9	21.8	15
	Mean	21.99	20.19	15.26	12.5
	Stand.Deviation	5.231	3.212	3.248	2.051
	Variation Coef.	23.7 %	15.94 %	21.27 %	16.41 %
B	Minimum	17.4	22.6	13.6	13.9
HEIGHT of BODY WHORL	Maximum	41.3	38.6	31	20.8
	MEAN	31.9	31.86	21.49	17.61
	Standad Deviation	7.479	4.75	4.846	2.678
	Variat.Coef.	23.44 %	14.90 %	22.50 %	15.20 %
S	Minimum	4.36	5.3	4.4	4.3
HEIGHT of the SPIRE	Maximum	11.5	10.4	9.1	9.7
	MEAN	7.24	8.17	6.07	6.27
	Stand.Deviation	1.911	1.624	1.3	1.981
	Variation Coef.	26.39 %	19.88 %	21.39 %	31.57 %
AA°	Minimum	87	77	72	73
APICAL ANGLE °	Maximum	112	101	98	90
	MEAN	99	90.4	89.8	80.2
	Stand.Deviation	7.191	6.111	6.947	6.159
	Variation Coef.	7.26 %	6.76 %	7.74 %	7.67 %
	Confid.Interval 95%	84.6> <113.4	78.2> < 102.6	75.9> <103.7	67.9> <92.5
W	Minimum	1.3	1.62	1.02	0.75
WEIGHT	Maximum	17.78	12.24	6.95	2.92
(gr)	MEAN	7.92	6.21	3.01	1.706
	Stand.Deviation	4.79	2.872	1.67	0.832
	Variation Coef.	60.45 %	46.21 %	55.47 %	48.70 %
PC	Minimum	1.8	1.9	1.5	1.1
DEPTH of the	Maximum	7.8	4.4	3.5	3.2
PALLEAL CHANNEL	MEAN	4.58	3.17	2.74	1.812
	Stand.Deviation	1.486	0.717	0.512	0.775
	Variation Coef.	32.56%	22.62%	18.71%	42.78%
H/LD	Minimum	1.648	1.789	1.693	1.82
	Maximum	1.869	2.15	1.927	2.033
	MEAN	1.786	1.987	1.807	1.906
	Stand.Deviation	0.061	0.087	0.066	0.074
	Variation Coef.	3.42 %	4.36 %	3.63 %	3.87 %

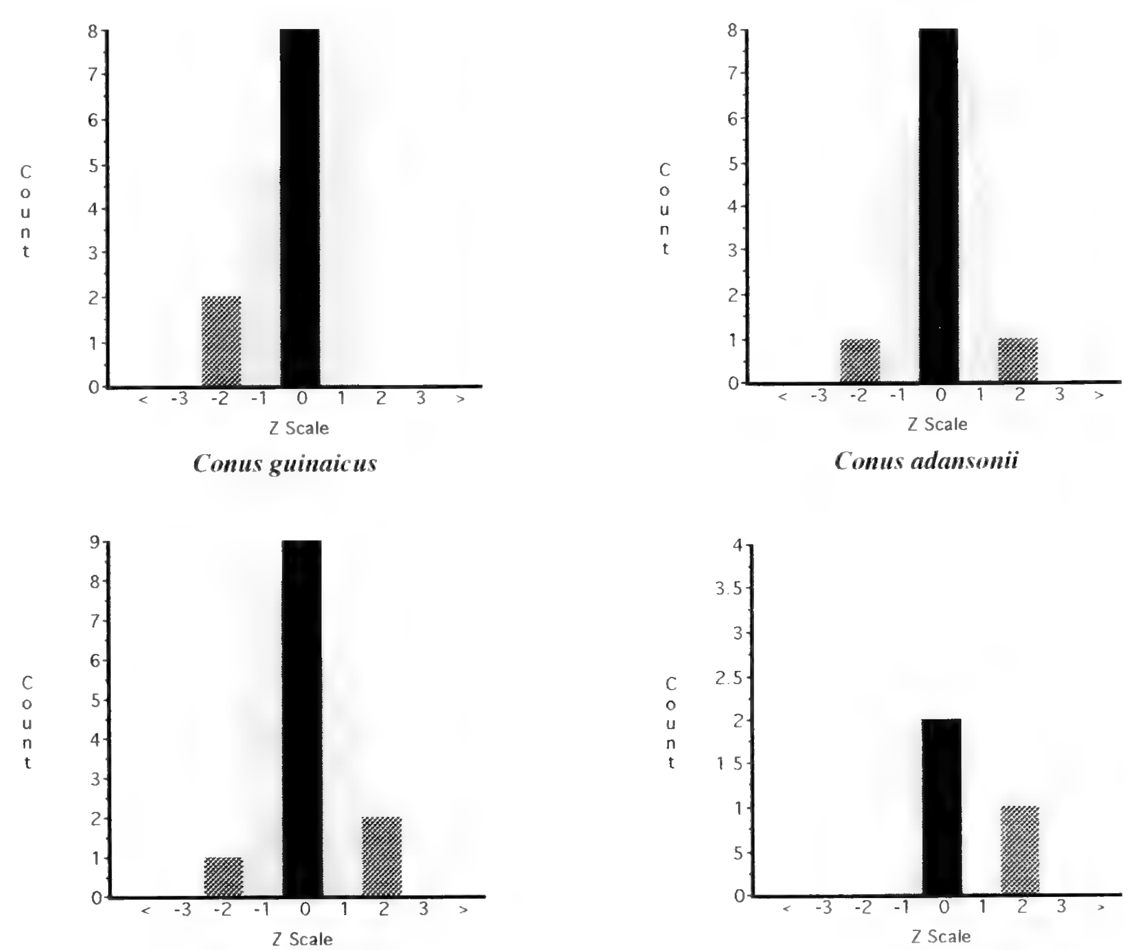
TABLE II : MORPHOMETRIC COMPARISONS (Continuation)

		C.guinaicus	*C.adansonii*	*C.guanche*	*C.g.nitens*
RSH	Minimum	0.143	0.155	0.167	0.216
RELATIVE SPIRE	Maximum	0.249	0.245	0.28	0.318
HEIGHT	MEAN	1.186	0.204	0.222	0.258
(S/H)	Stand.Deviation	0.029	0.025	0.028	0.039
	Variation Coef.	15.61 %	12.07 %	12.56 %	15.11 %
RD	Minimum	0.648	0.59	0.671	0.667
RELATIVE DIAMETER	Maximum	0.747	0.679	0.761	0.757
of the BODY WHORL	MEAN	0.692	0.634	0.713	0.709
(LD/B)	Stand.Deviation	0.024	0.024	0.02	0.027
	Variation Coef.	3.48 %	3.77 %	2.78 %	3.77 %
W/H	Minimum	0.058	0.057	0.055	0.04
	Maximum	0.341	0.254	0.181	0.098
	MEAN	0.185	0.149	0.103	0.068
	Stand.Deviation	0.082	0.052	0.035	0.022
	Variation Coef.	44.28 %	35.0 %	33.96 %	32.44 %
RPE	Minimum	0.103	0.054	0.08	0.074
RELATIVE PALLEAL	Maximum	0.189	0.135	0.198	0.155
EXPANSION	MEAN	0.141	0.1	0.131	0.101
(PC/B)	Stand.Deviation	0.022	0.019	0.028	0.033
	Variation Coef.	15.63 %	19.27 %	21.75 %	33.06 %
RWE	Minimum	1.109	1.109	1.103	1.126
RELATIVE WHORL	Maximum	1.209	1.21	1.191	1.184
EXPANSION	MEAN	1.174	1.171	1.154	1.155
(LD/SD)	Stand.Deviation	0.021	0.02	0.022	0.017
	Variation Coef.	1.83 %	1.72 %	1.89 %	1.44 %
AE	Minimum	0.065	0.059	0.066	0.079
APERTURE EXPANSION	Maximum	0.121	0.117	0.118	0.109
[(LD-SD)/B]	MEAN	0.102	0.093	0.095	0.095
	Stand.Deviation	0.011	0.011	0.011	0.01
	Variation Coef.	10.98 %	12.31 %	11.95 %	10.24 %
RBA °	Minimum	24.19	23.02	25.91	28.37
RELATIVE BASAL ANGLE	Maximum	38.09	35.09	39.69	38.12
2*[tan-1 [(RSD/2) /B]	MEAN	29.88	28.84	31.65	32.59
	Stand.Deviation	3.461	2.735	3.014	3.643
	Variation Coef.	11.58 %	9.48 %	9.52 %	11.18 %
RSA °	Minimum	109.63	113.55	112.15	119.58
RELAT.SPIRAL ANGLE	Maximum	123.67	127.06	128.26	127.83
[360°-(AA+RBA)] /2	MEAN	115.56	120.38	119.29	123.58
	Stand.Deviation	3.586	3.202	3.705	2.455
	Variation Coef.	3.10 %	2.66 %	3.10 %	1.99 %

TABLE III - MORPHOMETRIC CORRELATIONS

		C.guinaicus	*C.adansonii*	*C.guanche*	*C.g.nitens*
H - LD	covariance	45,91	18,127	18,623	8,861
	correlation	0,987	0,956	0,986	0,978
H - W	covariance	40,15	15,687	9,295	3,603
	correlation	0,956	0,927	0,958	0,981
AA - S	covariance	-6,177	-5,937	-1,087	-10,493
	correlation	-0,449	-0,598	-0,121	-0,86
AE - RWE	covariance	0,000226	0,00022	0,000239	0,00015
	correlation	0,939	0,961	0,973	0,928
RSD - H	covariance	30,987	13,468	14,961	9,529
	correlation	0,911	0,869	0,91	0,942

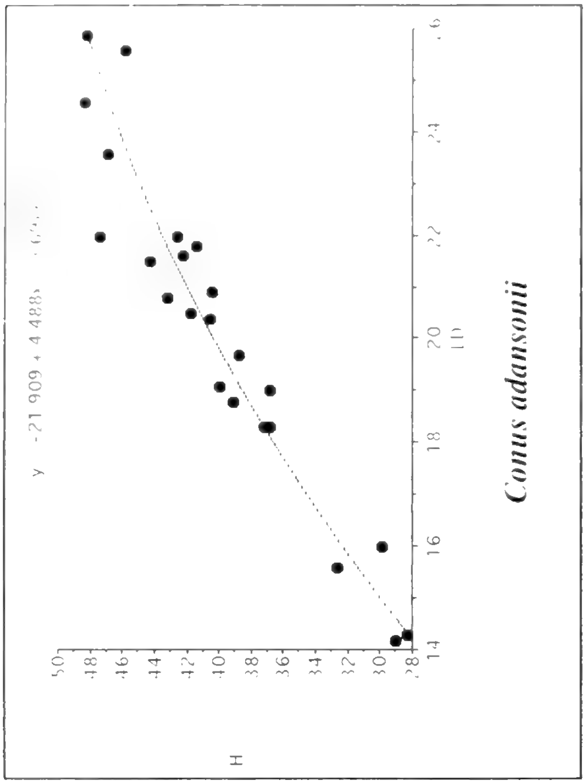
GRAPHS I - Z Score of H/LD



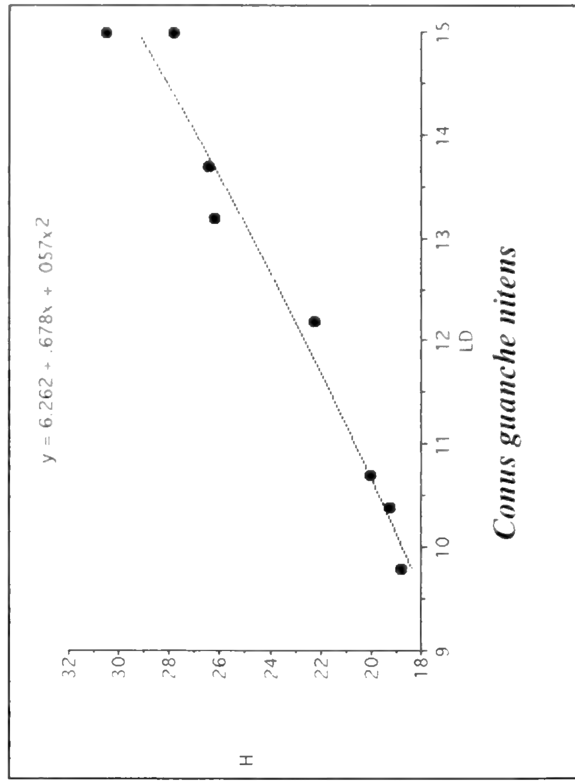
Conus guinaicus *Conus adansonii*

Conus guanche *Conus guanche nitens*

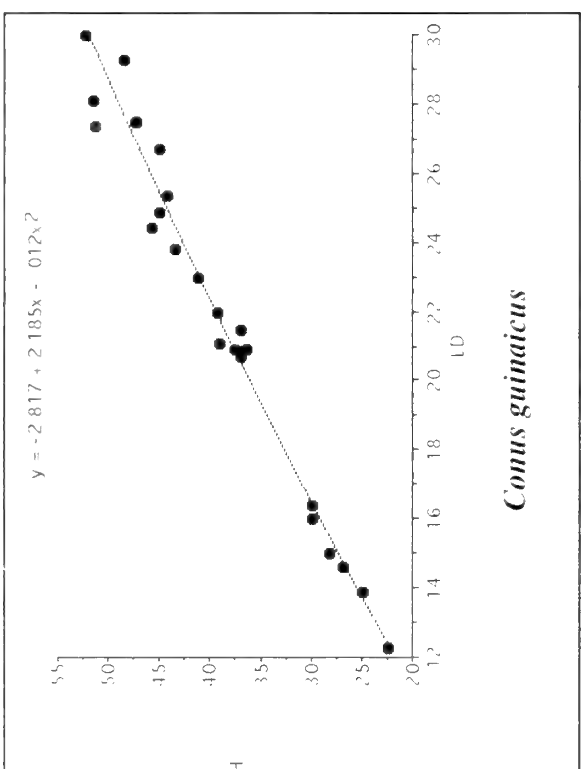
GRAPHS II: POLINOMIAL REGRESSION of H and LD



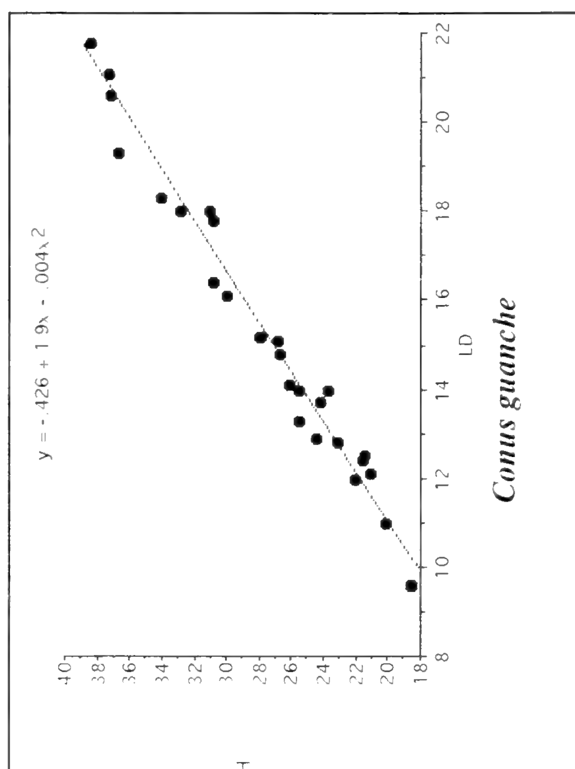
Conus adansonii



Conus guanche nitens

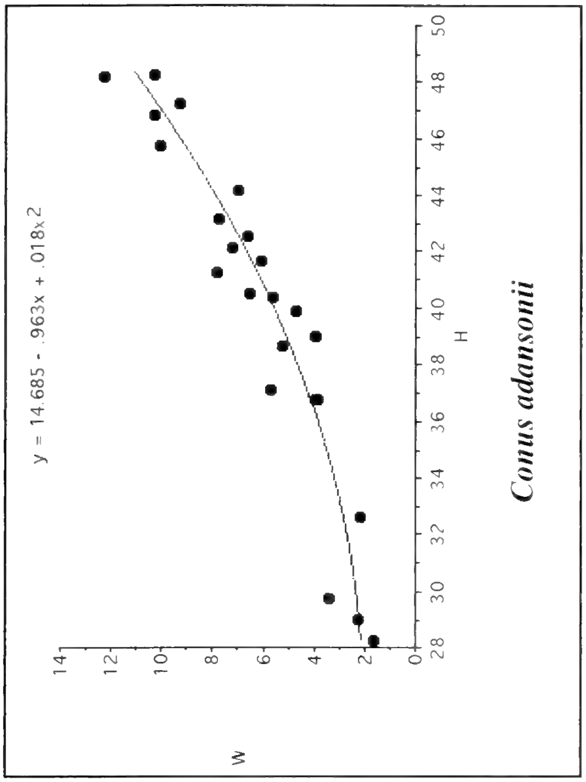


Conus guinaicus

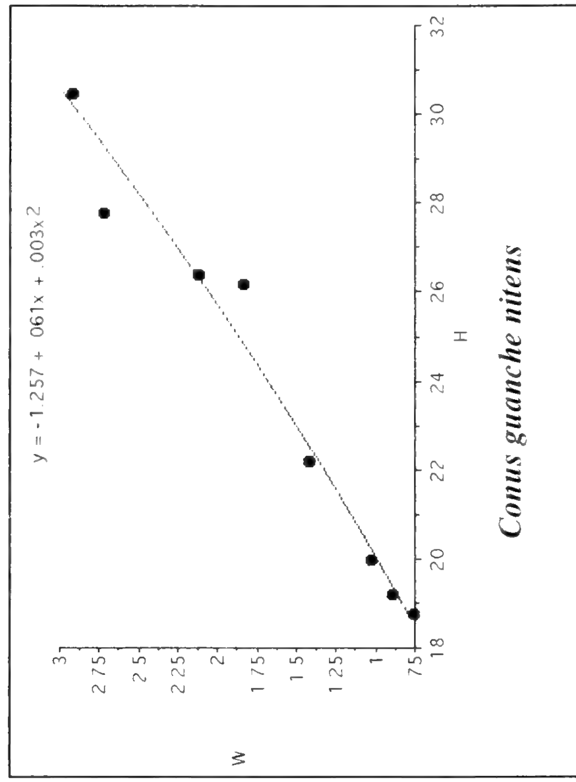


Conus guanche

GRAPHS III: POLINOMIAL REGRESSION of W and H



Conus adansonii



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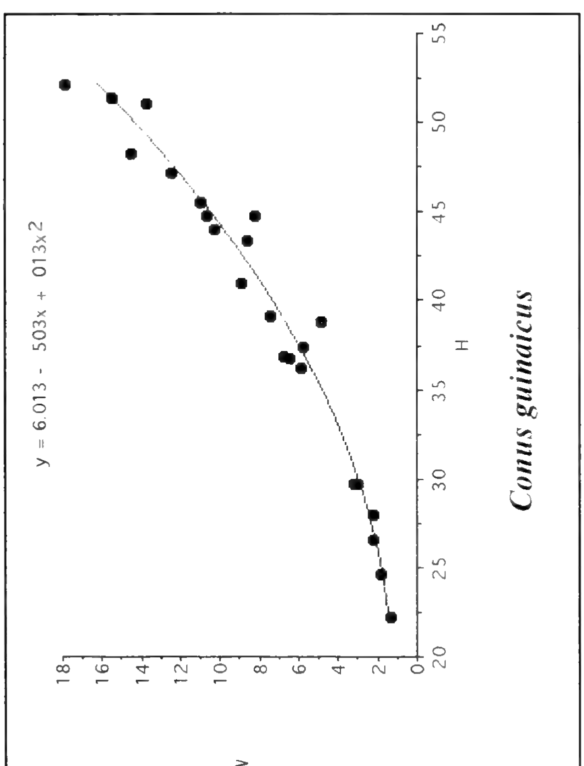

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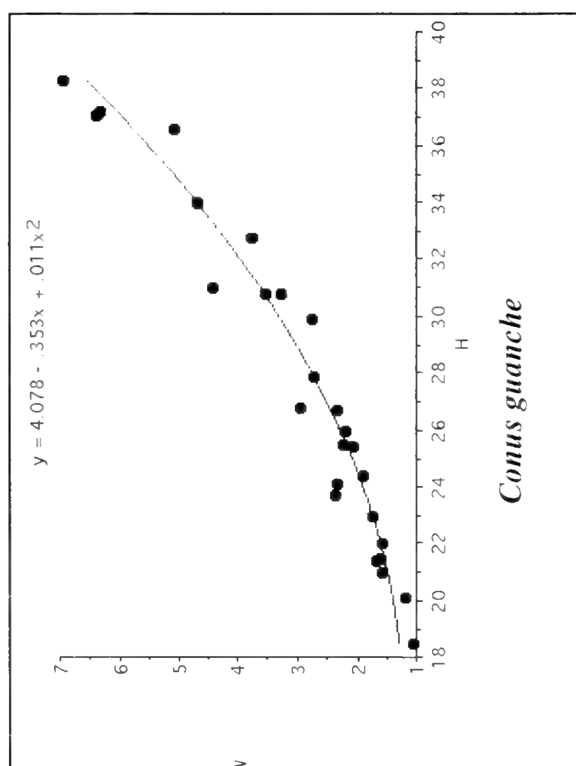

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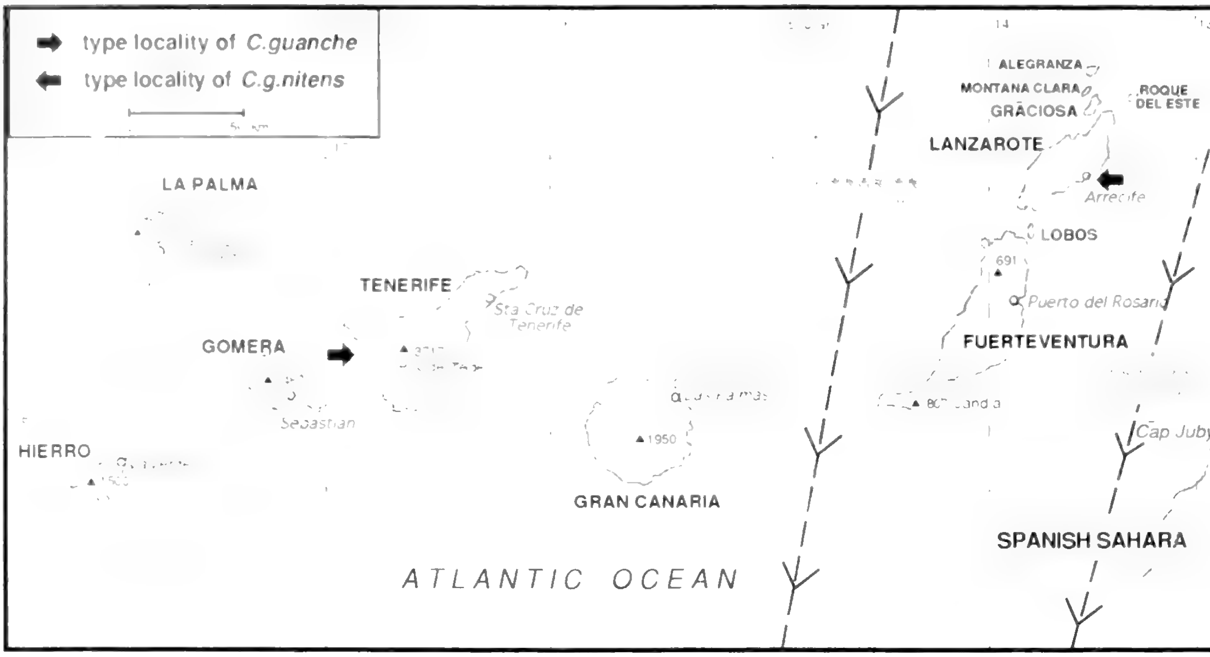


Fig 1 - Map of the Canary Islands

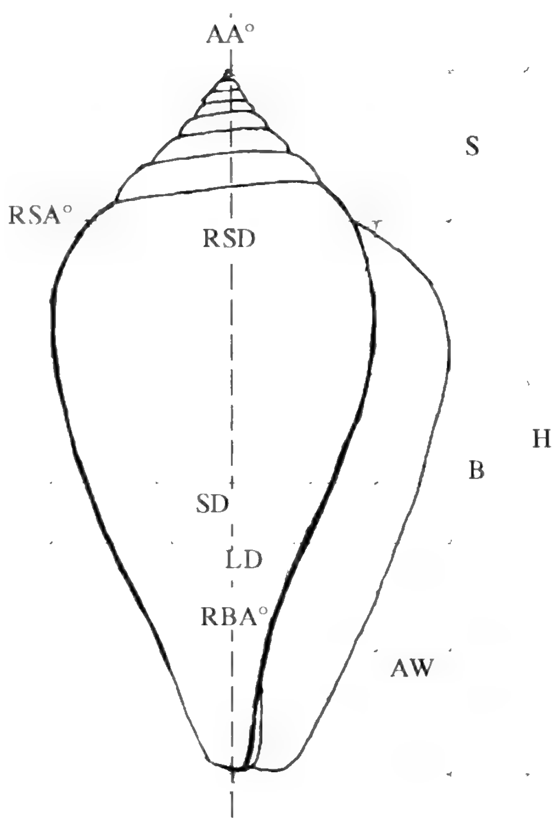
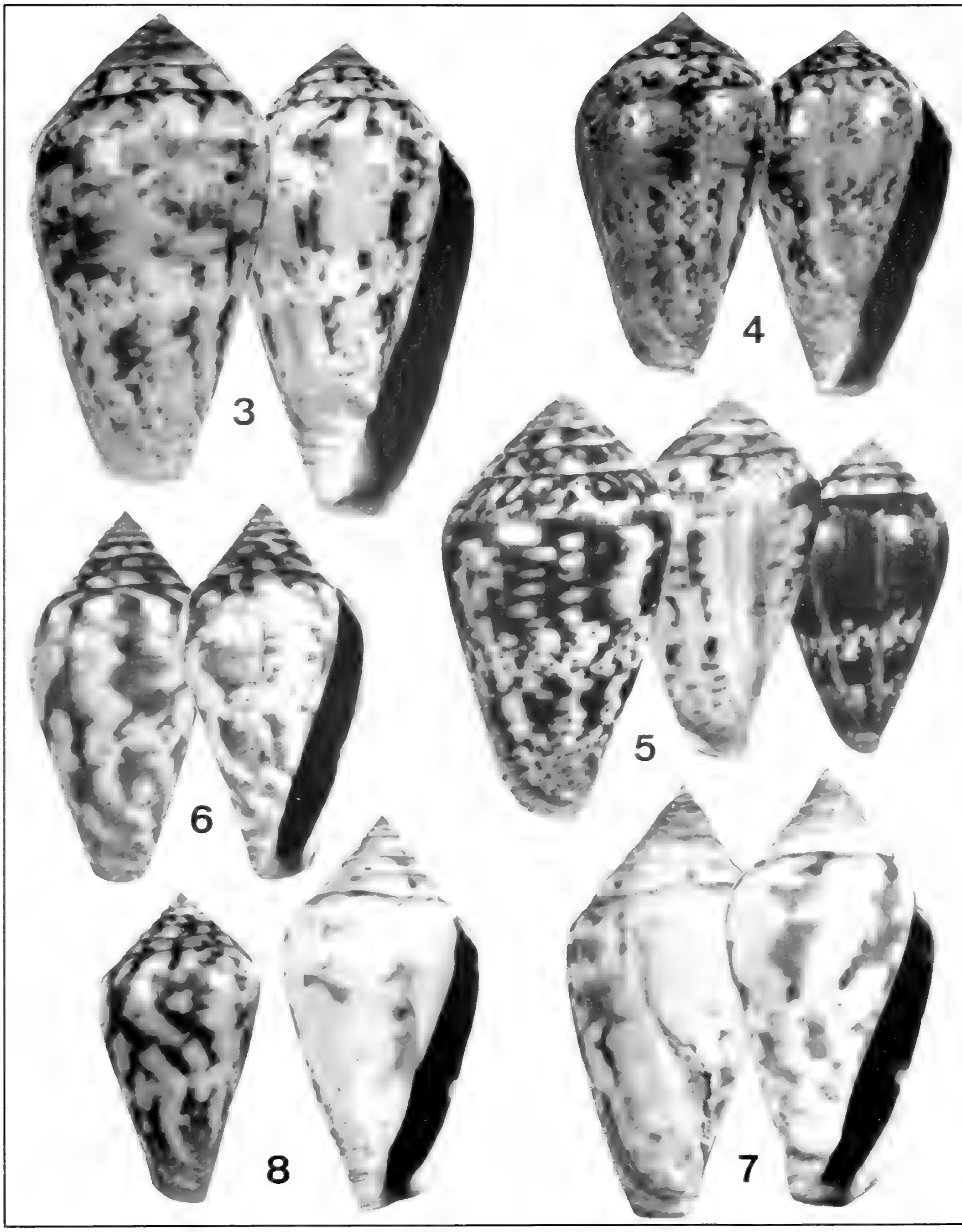
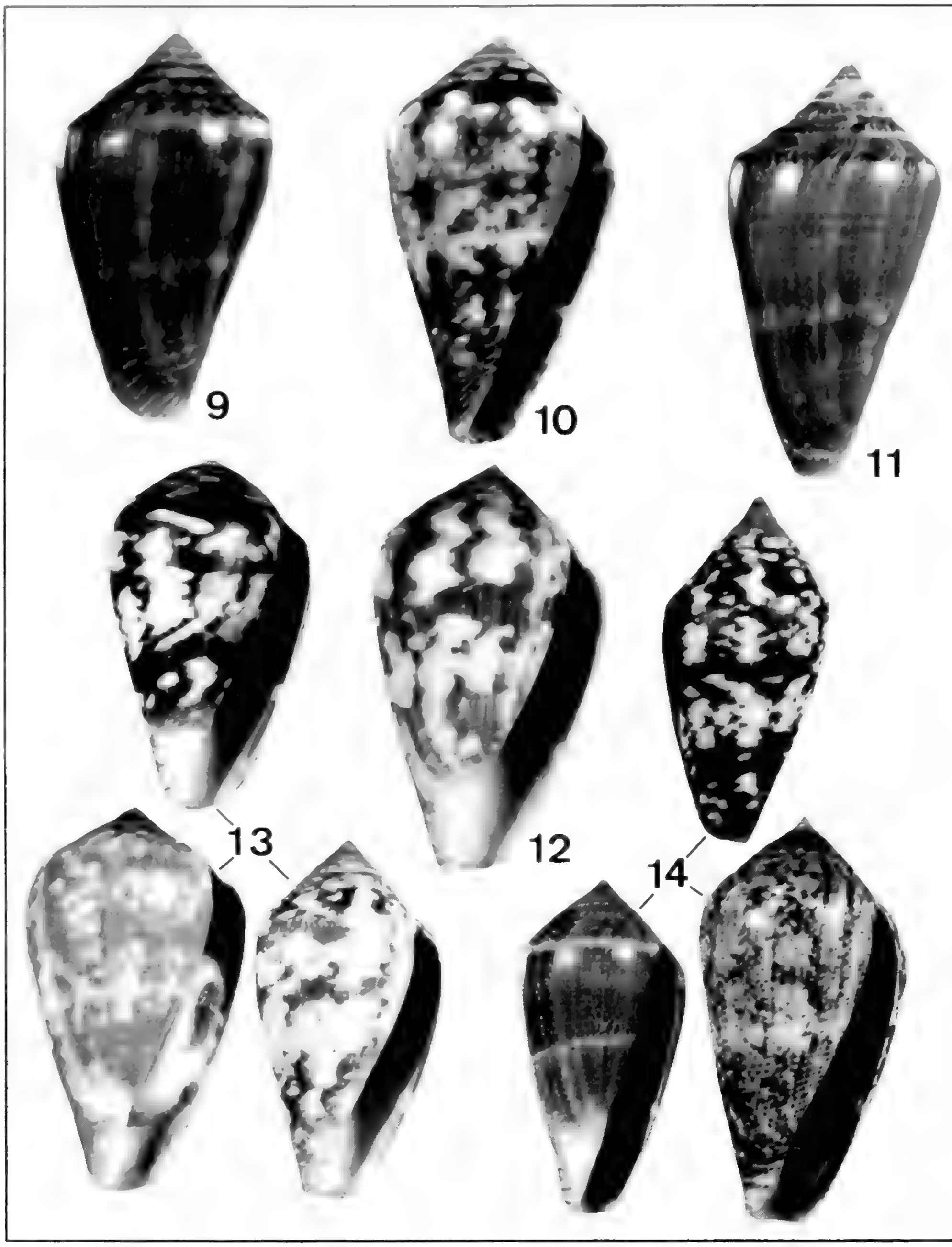


Fig. 2
MORPHOMETRIC MEASURES AND RATIOS

H - Height of the shell
LD - Largest Diameter
SD - Smallest Diameter
B - Height of the Body Whorl
S - Height of the spire = H-B
AW - Aperture Width = LD-SD
AA - Apical Angle (in degrees)
W - Weight (in grammes)
PC - Dephi of the Palleal Channel
H/LD - Height / Largest Diameter
RSH - Relative Spire Height = S / H
RD - Rel. diameter of the Body Whorl = LD / B
W/H - Rel. Weight = W (gr.) / H (mm.)
RPE - Rel. Palleal Expansion = PC / B
RWE - Rel. Whorls Expansion = LD / SD
AE - Aperture Expansion = AW / B
RSD - Rel. Spire Diameter = 2 * [S * tan (AA/2)]
RBA - Rel.Basal Angle = 2 * [$\tan_{-1}$ ((RSD/2) /B)]
RSA - Rel. Spiral Angle = [360° - (AA+RBA)] /2



Figs. 3-8.
Fig. 3 - *Conus guanche* - holotype (34 mm) .Punta Blanca, Tenerife, Canary Islands. **Fig. 4** - *Conus guanche* - paratype n° 1 (26,6 mm) Punta Blanca, Tenerife, Canary Islands. **Fig. 5** - Variability of *Conus guanche* - (from left to right : 27,9 - 24 and 21 mm) Punta Blanca, Tenerife, Canary Islands (coll. Lauer). **Fig. 6** - *Conus guanche* nitens - Holotype (26,2 mm) Isleta de los Ingleses, Arrecife, Lanzarote, Canary Islands. **Fig. 7** - *Conus guanche nitens* - paratype n° 1 (30,5 mm) Isleta de los Ingleses, Arrecife, Lanzarote, Canary Islands. **Fig. 8** - Variability of *Conus guanche nitens* - left : Arrecife, Lanzarote (22,2 mm) - right : Lanzarote (27,8 mm), Canary Islands (coll. Lauer).



Figs. 9-14.
Fig. 9 - *Conus* aff. *guanche* - (18,9 mm) Agaete, Gran Canaria Canary Islands (coll. Lauer). **Fig. 10** - *Conus xicoi* - (22 mm) Angola (coll. Lauer). **Fig. 11** - *Conus (mediterraneus ?) desidiosus* - (27,4 mm) Lampedusa Island, Italy (off Tunisia) (coll. Lauer). **Fig. 12** - *Conus guinaicus* - (45,5 mm) Tenerife, Canary Islands (coll. Lauer). **Fig. 13** - *Conus guinaicus* - variability - (44,1, 44,9 and 43,6 mm) Petite Côte, Sénégal (coll. Lauer). **Fig. 14** - *Conus adansonii* - variability - (41,6, 40,6 and 48,2 mm) N'Gor, Senegal (coll. Lauer)

The distribution of molluscs in beach deposits as identification of recent evolution in the littoral

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KEYWORDS. Belgian coast, wadden, mollusc distribution, beach deposits, recent geology, ecological affinity.

MOTS-CLEFS. Côte belge, wadden, distribution des mollusques, laisse de mer, géologie récente, affinités écologiques.

ABSTRACT. Several factors are responsible for the distribution of the malacological fauna on the beaches of our coast.A detailed analysis of this fauna (4309 individuals from 93 species), sampled in the mean tide level on the beach over a distance of 6 km (starting from the harbour of Ostend towards Klemskerke), shows the presence of marine, brackishwater, freshwater shells together with landsnails. After grouping the different species with reference to their ecological affinity, distribution histograms were made and a statistical analysis was executed. Due to these distribution tests the unexpected presence of freshwater and brackishwater species has been corresponded with the existence in the past of outflow channels and a wadden landscape. Such type of analysis seems to give very good complementary research tools for the study of the recent geology of the coast and for local archaeological investigations.

RESUME. Différents facteurs sont responsables de la distribution de la faunule malacologique sur les plages de notre littoral. L'analyse détaillée de cette faunule (4309 exemplaires comprenant 93 espèces), échantillonnée dans les laisses de mer et au niveau de l'estran, sur une distance de 6 km (depuis le chenal d'Oostende jusque Klemskerke), révèle la présence de coquilles marines, d'eau saumâtre, dulçaquicoles et terrestres. Des histogrammes de répartition des échantillons ont été dressés et leur analyse statistique a été effectuée en groupant les différentes espèces suivant leur affinité écologique. A la lumière de ces tests de répartition, la présence insolite d'espèces d'eau douce et saumâtre a pu être mise en rapport avec l'existence de chenaux d'écoulements et de systèmes lagunaires anciens. De telles analyses se révèlent être de bons outils d'investigations complémentaires pour les études de la géologie récente du littoral ainsi que pour les recherches archéologiques locales.

SAMENVATTING. Verschillende factoren zijn verantwoordelijk voor de verdeling van de molluskenfauna op de stranden van onze kust. De gedetailleerde analyse van deze fauna (4309 stuks met 93 soorten), waarbij steekproeven genomen werden op het niveau van het strand en in de vloedlijn over een afstand van 6 km (vanaf de haveningang van Oostende tot Klemskerke), doet ons de aanwezigheid van mariene schelpen, brakwater- en zoetwater- soorten en landslakken vaststellen. Na groepering van de verschillende soorten volgens hun ecologische affiniteit werden verdelingshistogrammen van de steekproeven ongesteld en werd een statistische analyse uitgevoerd. Dankzij deze verdelingstesten werd de onverwachte aanwezigheid van zoetwater- en brakwatermollusken in verband gebracht met het bestaan van vroegere afwateringsgeulen en lagunaire systemen. Zulke analyses blijken zeer goede complementaire onderzoekswerktuigen te zijn voor de studie van de recente geologie van de kust en voor lokaal archeologisch onderzoek.

INTRODUCTION

For many years (since 1976), the authors have been undertaking malacological analyses along the sandy shores of the Southern North Sea (Belgian coast).

When sieving beach sand, many shells are found in the size fractions of less than 5 mm. Besides protoconchs and small specimens belonging to the seabottom fauna, significant quantities of shells typical for brackishwater, freshwater and even for the land environment are found. Among the typical marine species most are living or dead juvenile forms of molluscs commonly found along the coast, other delicate specimens belong to much less common or even rare species.

The present paper deals with the molluscs species originating from brackishwater, freshwater and land. For them the sea shore may be considered as a tapho- or tanathocoenosis.

This surprising heterogeneity of the malacological faunula of the beach suggests the occurence of many phenomena responsible for this distribution.

The general tidal and residual circulation in the Southern Bight of the North Sea is well documented (especially since the Belgian research program "Mathematical model of the North Sea").

Vectors carrying non marine shells to the sea could be the large rivers of the delta (Scheldt, Meuse, Rhine) or other local rivers with a less important flow like the Aa or the Yser.

On a smaller and more locale scale, outflow channels collecting waters, mostly brackish, caught in the reclaimed land of the coastal plain (polders") by the ditches ("wateringen"), and draining them to the estuaries or into harbours (Dunkirk, Ostend, Zeebrugge,...), could also carry some shells to the littoral.

Erosion may also be taken into account for explaining the presence of non-marine shells among the beach sediments.

In such case, while the seabed is eroded subfossil molluscs are extracted, worked by waves and streams and locally deposited together with recent marine shells on the beaches.

The present work demonstrates that the latter mechanism is likely to occur. The spatial and quantitative distribution of the non-marine molluscs among the beach deposits thus helps to describe the past geomorphology of the studied seashore.

MATERIAL AND METHOD

In order to describe the distribution of all the malacological components of the shore (living, dead and remains) to analyse their ecological origin and to deduce the mechanism leading to their accumulation in the sediments on the beach, we sampled beach sand and deposits at mean tide level along 5 km line

running East of Ostend (starting at kilometer post 31) towards Klemskerke; the interval between the samples was 1 km. In this context our 6 sampling stations are called 31 to 36 inclusive. In this region the residual tidal nearshore circulation is moving Eastwards.

A first sampling on 19 and May 1976 was followed by a new one on 20 May 1977. At each station, 90 cm3 of superficial sediments were collected with a spatula and fixed in 10% formalin in order to preserve the live specimens.

This large bulk of material has been completely examined under a dissecting microscope. All the living molluscs, shells and fragments of shells were sorted, identified and counted at the species level. Besides the taxonomic analysis all the species were classified according to the ecological environment to which they belong.

We can define 8 classes:

1. Species from dry biotopes (dunes).
2. Species from dry biotopes with humid characteristics (bushes, groves).
3. Species from humid biotopes (permanently humid depressions, wateredges).
4. Freshwater species tolerating very low salinity.
5. Brackishwater species tolerating freshwater.
6. Brackishwater species.
7. Marine species tolerating low salinity.
8. Marine species.

If we consider also the 2 samples of 1976 we can even introduce a 9th class, namely the typical freshwater environment.

The observed frequencies for this class were however very small.

The statistical methods used for the classification and for the comparison between classes and stations, are described in sections 3 and 4 below.

ANALYSIS OF THE SAMPLES

Species and frequencies

The present analysis is based principally on the samples of 1977. These 6 samples gave a great number of specimens (4309) and a surprisingly high number of different species (93).

Table I gives for each species the present-day ecological class, the abundance and the frequency in the sample. Graphs drawn for each ecological class show the frequency of all the species at each station along the sampling line. Terrestrial, freshwater and brackishwater classes are described and discussed below.

Terrestrial molluscs

To the land molluscs belong typical dry land species which live in xerophytic dunes environments. Among them, *Hellicella* spp. are indicator species.

Land molluscs from wet environments are also present. These species are living in old dunes covered with bushes and woods or close to ponds. Typical species are *Zonitoides excavatus* and *Trichia hispida*.

Although the biomass of living molluscs is rather low in dunes, the soil contains numerous dead shells. They are well preserved since these dunes are made of carbonate sand. The presence of these remains are indicators of previous environmental conditions which in dunes may change from dry to wet.

Fig. 1 shows peaks of occurrence of land species at station 33 (2,5% of species from dry dunes), station 35 (3,6% of species from dry dunes) ans station 36 (2,3% of species from humid dunes).

Freshwater and brackishwater molluscs

We put together in one group the non-marine aquatic species. To them we added the land species from permanent humid biotopes like marshlands and wateredges which may remain submerged such as *Succinea elegans*.

Among the freshwater species able to support brackish water, *Lymnaea ovata* is a typical example. In the present study not one species living exclusively in freshwater was found in the six samples of May 1977. Some were, however, found in the 1976 samples (see the appendix). A typical brackishwater species able to tolerate freshwater is *Potamopyrgus jenkinsi*.

In Fig. 2, we see a distinct rise of the total number of freshwater and brackishwater species, when going from station 31 to 36. At station 36 this group constitutes 11,6% of the species. It is worth noting that this rise occurs as one moves eastwards away from the entrance of the Ostend harbour (the place where the land runoff occurs). This seems a rather surprising pattern since one could expect a decrease of the species of class 6. There is however no evidence for such a decrease.

Many arguments might be considered for explaining such a distribution pattern: the vicinity of the runoff at Ostend, the relative distance of the Scheldt estuary and the direction of the residual current along the shore. Not one of them gives a satisfactory explanation for the presence of increasing amounts of fresh- and brackishwater species to the East. Another surprising fact is the sensible reduction in the number of strictly marine species at station 31 (Fig. 3) to the benefit of an increasing number of marine species able to tolerate varying salinities. In the histogram the modes for both classes are clearly separated in such a way that, when taking into account other environmental factors like currents, we can not assert that there is any influence from the Ostend harbour system. The observed distribution may only result from local erosion. Such a mechanism is quite explainable when we consider the historical evolution of the geomorphology along this part of the littoral.

STATISTICAL ANALYSIS

The distribution analysis given above is based on frequencies of occurrence in the sample of species originating from environments which are completely different. This analysis has given us already strong indications to exploit the observed distribution. A more powerful tool in checking the homogeneity of the studied region is a correlation analysis. Due to the non-single distribution a correlation coefficient can't be calculated. It is however possible to achieve this aim by using a method in which the single distribution is not necessary: the contingency coefficient also called the "Pearson's coefficient of mean square contingency".

$$C = \sqrt{\frac{T}{N+T}} \quad \text{(Conover)}$$

$$T = \sum_{i=1}^{k} \sum_{j=1}^{r} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

k : total number of samples

r : total number of species in the k samples

O_{ij} : observed number of individuals of species j in sample i

E_{ij} : theorical number of individuals of species j in sample i and with

$$N = \sum_{i=1}^{k} \sum_{j=1}^{r} O_{ij}$$

The theorical numbers E_{ij} however are unknown but can be approximated. Therefore we take all the studied samples together and calculate the probability to find each observed species in all the samples in the following way

$$P\,(\text{species}\,j) = P = \frac{\sum_{i=1} O_{ij}}{\sum_{i=1}^{K} \sum_{j=1}^{R} O_{ij}}$$

where K : all the observed samples
R : all the observed species

when

$$N_i = \sum_{j=1}^{R} O_{ij}$$

being the total number of individuals in sample i, the theorical values E will be $_{ij}$ found as

$$E_{ij} = N_i . P_j$$

The calculation of the contingency coefficient has been executed for the observed species. It is also possible to check the

dependence between the samples when we consider the ecological classes, as defined above, instead of the species.

The theorical values for C are $O < C < 1$. In the species approach max C will be 0.99, when in the class approach max $C = 0.9$.

If the value of C is close to the maximum, a great affinity between the samples exists. If C is close to 0, the samples are considerably different.

The results of the calculation of C for both species and class approaches are listed in table II. This table shows us decrease of the C values between stations 33 and 35 which is an indication that in this area of the shore the distribution of species and their ecological grouping are signicantly different when compared to the other parts of the sampling line.

It is however clear that our samples are not strictly independent because of the discretisation of the area when taking the samples. Therefore we have to test the differences beween correlated samples. Due to the great number of individuals of a few species another basic assumption has to be used. Since our analysis is dealing with ecological classes concerning different environments, the number of individuals is not the selective determinant. The presence or the absence of a certain species or class is however a better potential characteristic. The best statistical test for this type of data is the Cochran Q statistic. This test is a chi-square test of homogeneity proportions for qualitative variables in correlated samples.

If we consider S samples and M species, we can build a table as shown hereafter:

with x_{ms} having the values 0 or 1.

$$T_{m.} = \sum_{s=1}^{S} x_{ms}$$

$$T_{.s} = \sum_{m=1}^{M} x_{ms}$$

Starting from these values we can calculate

$$T_{..} = \frac{1}{S} \sum_{m=1}^{M} \sum_{s=1}^{S} x_{ms} = \frac{1}{S} \sum_{s=1}^{S} x_{.s}$$

then

$$Q = \frac{S(S-1)\left(\sum_{s=1}^{S} (T_{.s} - T_{..})\right)}{\left(S \sum_{m=1}^{M} T_{M.}\right) - \left(\sum_{m-1}^{M} T_{m.}^{2}\right)}$$

is appproximately X^2 distributed with $V = S-1$

sample / species	1	2	3		s		S	Totals
1	x_{11}	x_{12}	x_{13}	...	x_{1s}	...	x_{1S}	$T_{1\cdot}$
2	x_{21}	x_{22}	x_{23}	...	x_{2s}	...	x_{2S}	$T_{2\cdot}$
3	x_{31}	x_{32}	x_{33}	...	x_{3s}	...	x_{3S}	$T_{3\cdot}$
.	.	.	.	...	.	...		
.	.	.	.	...	.	...		
m	x_{m1}	x_{m2}	x_{m3}	...	x_{ms}	...	x_{mS}	$T_{m\cdot}$
	.	.	.	...	.	...		
	.	.	.	...	.	...		
M	x_{M1}	x_{M2}	x_{M3}	...	x_{Ms}	...		$T_{M\cdot}$
Totals	$T_{.1}$	$T_{.2}$	$T_{.3}$	...	$T_{.s}$	...	$T_{.S}$	

is appproximately X^2 distributed with $V = S-1$ degrees of freedom. Since Q is X^2 distributed it can be used for hypothesis testing. For our purpose this is however not necessary since our conclusion can be derived from the comparison of the results. We know that the smaller the value of Q the bigger the correlation of the samples is and therefore the greater the affinity. We also applied the C Cochran Q test on 2 samples according to the method called the "Mc Nemar test for the significance of changes (Siegel)". This Mc Nemar test is slightly different from the generalised Cochran Q for 2 samples as described in Marascuilo and Mc Sweeney. Both give approximately the same results. The Q-values in Table III have been obtained with the implementation of the test in SPSS (Statistical Package for the Social Sciences).

The slowly rising values of Q from station 31 towards the studdenly culminating point between stations 34 and 35 and the sharp fall afterwards indicates the existence of a particular local distribution in that part of the studied area. It will be shown afterwards that even the slowly rising Q-values between stations 31 and 34 can be explained.

DISCUSSION

The presence of freshwater and brackishwater species at some locations of our sampling line, revealed by the frequency distribution (table I) and confirmed by the statistical analysis appears to be local and is probably due to marine erosion. As discussed already above, hydrodynamical advections from rivers or sewage runoff should not be responsible for such particular distribution. Local erosion of the seabed may explain the presence of these molluscs with enough satisfaction. Such erosion is a common feature on the Belgian coast demonstrated clearly by the abundance, at some places, of conspicuous peatmass and clay balls accumulated in the beach deposits.

This erosive activity is mining subfossil wadden environments (with dunes, marshes, brackish lagoons and channels) extending presently under the seabottom along the flemish coastal maritime plain many movements of the sea, flooding over the coastal brackish environments and retiring after a short or a longer period, happened during the holocene. The second Dunkirkian sea transgression (Dunkirkian II) in the 4th century A.D. was the last important movement in the studied portion of the Belgian coast.

The presence in our sampling line of a narrow localised area, characterised by the particular mollusc composition in the beach deposits, is related to the existence at the same place of a channel of the wadden landscape, existing before the last transgression.

In order to check this possible correlation, we did compile numerous archaeological, historical and chart data listed in the bibliography.

To the East of Ostend, two main tidal channel systems are noticed. The first one, close to Ostend, is converging towards the harbour and its older defense systems; many parts of this system still remain inland (Grote Keiaard, Oude Straatkreek, Zoutekreek, etc.).

The second main channel, easternmost, is according to our compilations, flowing northeast from near Oudenburg and Ettelgem. The sea was reached between De Haan and Wenduine.

The main arguments for determining the area covered by this channel and creek are deduced from the present geomorphology especially the presence of low altitude meadows with turf soil (fig .4)

The eastern limit of this channel must lie east of De Haan (see fig. 4) probably where the actual shoreline bends slightly towards the northeast to Wenduine.

The Wenduine Bank, a rather stable and undeep offshore sandbank, lying a few miles off the actual coast line, is a strip on the past dune who formed the littoral in historical times as suggested by archaeological remains (pottery and potsherds) found there and which can be found occasionally washed ashore.

Behind these dunes a large creek open to the sea (the actual "Grote Rede") was at that time

collecting the tidal channels of this part of the coast.

The limits of these channel systems of the pretransgression wadden environment may also be traced by plotting on the chart (fig. 4) the localisation of the old farms and villages ("hoven"). They were built along these old channels (for communication) near their marshes whose productive meadows sustained sheep ranching and also close to the sandbanks where, due to the higer level, some agriculture could be practised. Nowadays, the distribution of both farming activities can still be seen on the aereal photograph (prepared by the Institut Géographique National). Moreover, the relief data and the farm locations given by the charts does correlate with the actual soil occupations: prominent culture zones and lower turf based meadows. The turf, which forms the basis of the low level meadow zones, has been dried by the digging of the "wateringen" system, collecting water throughout the whole region, and is therefore reducing in thickness. This particularity adds some sharpness in the delimitation of the depressed level of the past channel and marsh system.

We can deduce from this historical and geographical research that our sampling line, along the actual shore line, crossed a channel between stations 33 and 35. This clearly explains the presence of the sharp disturbance in the mollusc distribution.

The presence of species from so many different biotopes in the same eroded deposits indicates that all these environments were very close to each other. This is an argument in favor of the presence of a rather narrow tidal channel in connection with a small creek behind the dune line of which the remains are still present in the sea (the first range of sandbanks). According to the location of the main channel systems described above we suppose that the channel located north of Bredene (km 34) joined one of the bigger ones. It is however possible that the two main channels and the smaller one form together a delta of a river for which the general form in our region is respected. Scheldt, Meuse and Rhine are going from their sources to the north and turn west not so far from their mouth.

This can only be determined with additional research. We said already above that the Q-values are slowly increasing towards a cumulating point. Fig. 5 gives us a good indication to explain this fact. In the depthline of 4 meter we see a distinct flexion with direction east around km 34. It is therefore obvious that between Ostend and kilometer 34 the Q-values will increase since the residual tidal nearshore circulation is going east.

CONCLUSION

The analysis of the distribution of mollusc species collected along a part of the sandy shores of the Southern North Sea (Belgian coast) provides us with information concerning the past geomorphology of the nowadays sea bottom which is presently and locally submitted to erosion.

The faunal composition is rich, including besides marine ones, land, fresh- and brackishwater species. Their quantitative and spatial distribution indicates sharply (less than 1km resolution) the presence of a subfossil tidal channel belonging to the wadden environment which existed in the region before the last marine transgression and human diking activities. The location of this channel east of Ostend is confirmed by arguments from topography, toponymy, soil analysis, archaeaology and present distribution of agriculture practices. Such malacological analysis appears to be a complementary and useful tool for the investigation of recent geology and geomorphology of the littoral (transgressions, evolution of the shore line and dunes) as well as for archaeological research.

Acknowledgements

We would like to thank Dr. G. Houvenaghel (laboratory of biological oceanography, Université Libre de Bruxelles) for his advice and assistance during the elaboration of this work and the preparation of the manuscript. We are also indebted to Mr Cooreman, F. Lambert and E. Terwinghe for their technical assistance.

APPENDIX

Species found in the samples of 1976 and not present in the 1977 ones. They are listed following the classification given above with insertion of class 9 on his natural place. Within each class species are ordered systematically

Class 1: species from dry biotopes
Pupilla muscorum
Theba pisana
Hellicella intersecta

Class 3: species from humid biotopes
Succinea oblonga
Vertigo pygmaea

Class 9: typical freshwater species
Valvata piscinalis
Physa acuta
Anisus laevis
Anisus rotundatus

Class 4: freshwater species tolerating very low salinity
Bithynia leachii
Lymnaea truncatula
Anisus planorbis
Anisus albus
Anisus crista
Anisus contortus

Class 5: brackishwater species tolerating freshwater
Bithynia tentaculata

Class 7: marine species tolerating low salinity
Nucella lapillus

Class 8: marine species
Lacuna parva
Trivia europaea
Oenopota turricula
Chrysallida indistincta
Solecurtus chamasolen

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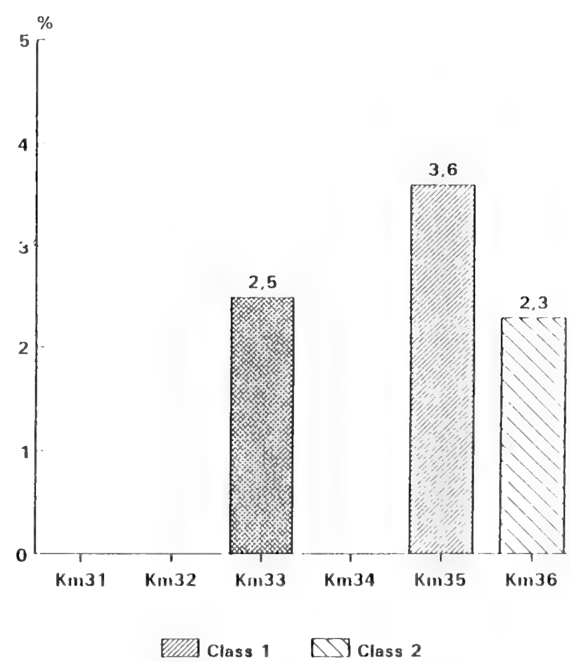

Fig. 1. Species of classes 1 and 2 compared to the total number of species.

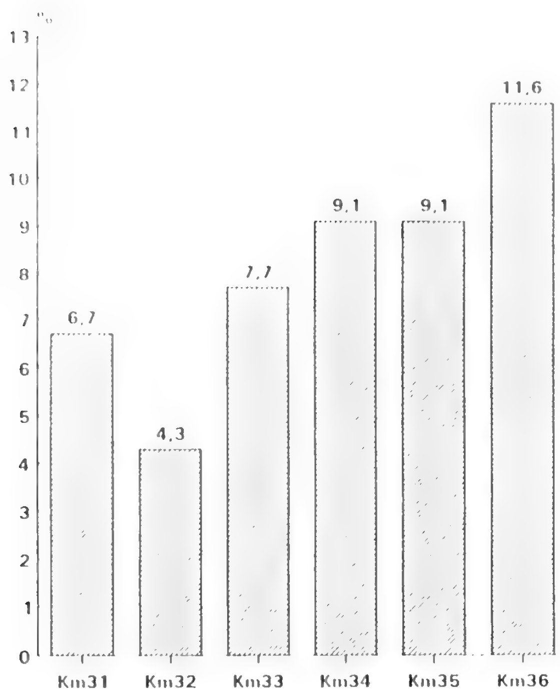

Fig. 2. Species of classes 3 to 6 included compared to the total number of species in each sample.

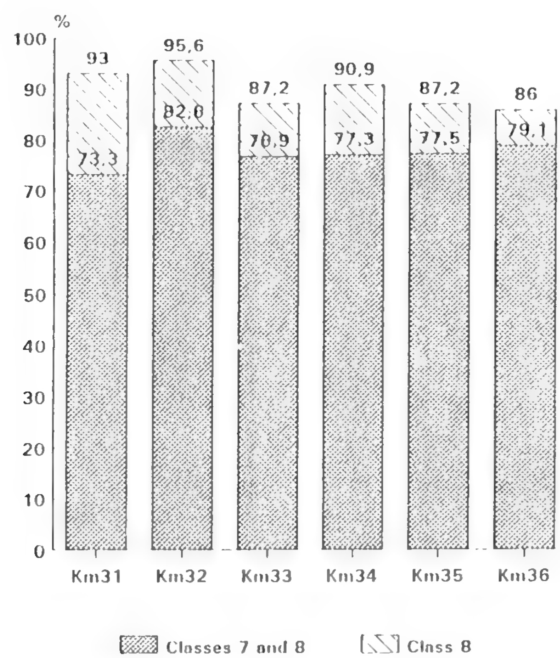

Fig. 3. Species of classes 7and 8 together and class 8 compared to the total number of species in each sample.

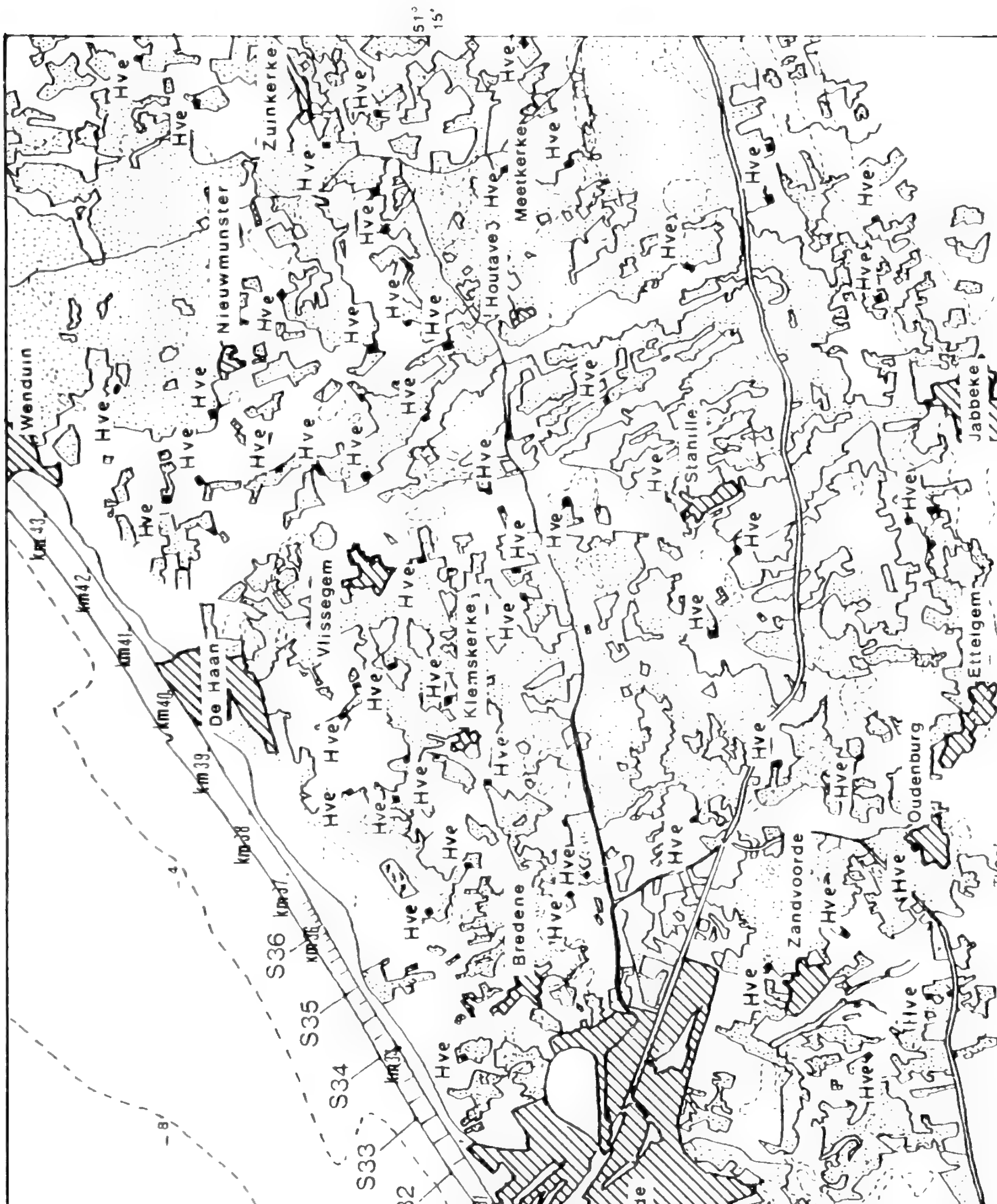

Fig. 4. Following the map of Belgium 1/25000 Sheets 4/7-8, 12/2 and 12/3-4 Institut Géographique National/ Nationaal Geografisch Instituut.

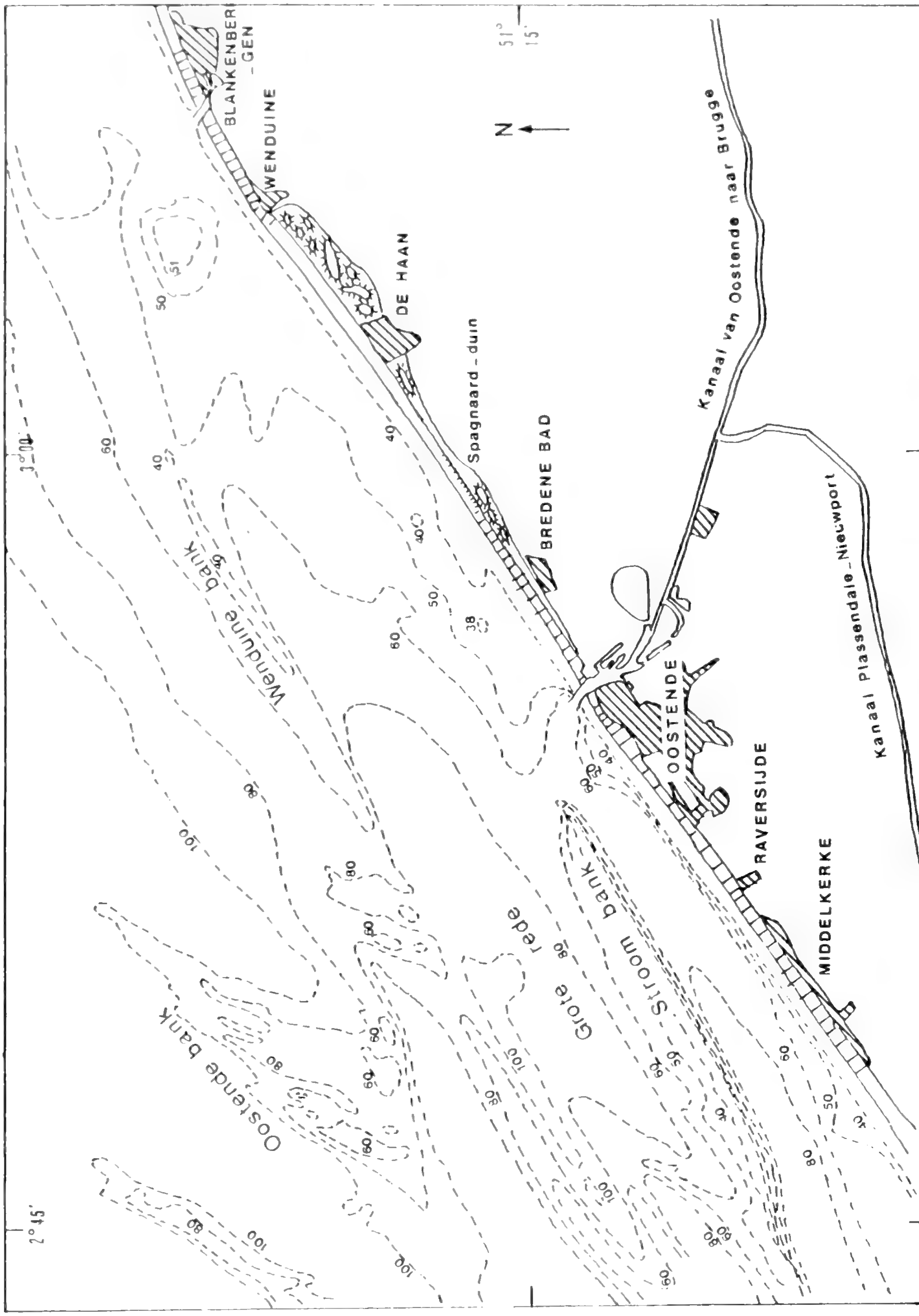

Fig. 5. Following the map "Noordzee Vlaamse Banken" collected from Belgian and foreign records of 1959-1979. 1/10000 Hydrologische Dienst der Kust.

TABLE I: Species and frequencies

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Vallonia excentrica Sterki,1892	1			1				1	1	0,023
Hellicella unifasciata (Poiret,1801)	1					1		1	1	0,023
Hellicella ericetorum (Müller, 1774)	1					1		1	1	0,023
Total class	**1**			**1**		**2**		**3**		**0,069**
Trichia hispida (Linné, 1758)	2			1				1	1	0,023
Zonitoides excavatus (Bean, 1830)	2						1	1	1	0,023
Total class	**2**			**1**			**1**	**2**		**0,046**
Succinea arenaria Bouch-Chant, 1827	3						1	1	1	0,023
Succinea elegans (Risso, 1826)	3						1	1	1	0,023
Totals class	3						2	2		0,046
Lymnaea ovata (Draparnaud, 1805)	4					1		1	1	0,023
Total class	**4**					**1**		**1**		**0,023**
Hydrobia jenkinsi Smith, 1889	5		2			9		11	2	0,26
Total class	**5**		**2**			**9**		**11**		**0,26**
Hydrobia ventrosa (Baster, 1765)	6			3		5	5	3	3	0,30
Hydrobia ulvae (Pennant, 1777)	6	19	26	76	3	40	11	175	6	4,06
Assiminea grayana Fleming, 1828	6				1	11	1	13	3	0,30
Total class	**6**	**19**	**26**	**79**	**4**	**56**	**17**	**201**		**4,66**
Littorina littorea (Linné, 1758)	7					1		1	1	0,023
Littorina saxatilis (Olivi, 1792)	7	1		2				5	3	0,12
Retusa obtusa (Montagu, 1803)	7					1		1	1	0,023
Mytillus edulis Linné, 1758	7	192	32	584	16	317	640	1781	6	41,33
Cerastoderma edule (Linné, 1767)	7	5	6	39	13	64	68	195	6	4,53
Macoma balthica (Linné, 1758)	7		3	18	9	3	11	44	5	1,02
Mya arenaria Linné, 1758	7					1		1	1	0,023
Total class	**7**	**198**	**41**	**643**	**38**	**389**	**719**	**2028**		**47,06**

TABLE I: Species and frequencies (continued)

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Emarginula fissura (Linné, 1758)	8					1		1	1	0,023
Acmaea virginea (O.F.Müller, 1776)	8		2		2	2	2	8	4	0,19
Gibbula magus (Linné, 1758)	8		1			1		2	2	0,046
Gibbula tumida (Montagu, 1803)	8					4		4	1	0,09
Gibbula umbilicalis (Da Costa, 1778)	8	2		1				3	2	0,069
Putilla soluta (Philippi, 1844)	8					7	1	8	2	0,19
Alvania semistriata (Montagu, 1808)	8					1		1	1	0,020
Rissoa inconspicua (Alder, 1844)	8					5	7	12	2	0,28
Rissoa parva (Da Costa, 1778)	8			5		8	2	15	3	0,35
Rissoa lilacina Reclus, 1843	8					2		2	1	0,046
Rissoa membranacea (J.A.Adams,1800)	8						1	1	1	0,023
Tornus subcarinatus (Montagu, 1803)	8				2	4		6	2	0,14
Skeneopsis planorbis (Fabricius, 1780)	8						1	1	1	0,023
Turritella communis Risso, 1826	8			1		4	1	6	3	0,14
Epitonium clathrus (Linné, 1758)	8	1				2		3	2	0,069
Epitonium clathratulum (Kanm., 1798)	8					2	1	3	2	0,069
Epithonium sp.	8		1					1	1	0,023
Capulus ungaricus (Linné, 1758)	8		1					1	1	0,023
Crepidula fornicata (Linné,1758)	8			1				1	1	0,023
Apporhais pespelicani (Linné,1758)	8					1		1	1	0,023
Lunatia catena (Da Costa, 1778)	8			2				2	1	0,046
Lunatia alderi (Forbes, 838)	8						2	2	1	0,046
Velutina velutina (Müller, 1776)	8		1				1	2	2	0,046
Ocenebra erinacea (Linné, 1758)	8					1		1	1	0,O23
Buccinum undatum Linné, 1758	8			1				1	1	0,023

TABLE I: Species and frequencies (continued)

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Hinia reticulata (inné, 1758)	8						1	1	1	0,023
Retusa truncatula (Bruguièra, 1792)	8			1		1	1	3	3	0,069
Chrysalida obtusa (Brown, 1827)	8					2		2	1	0,046
Odostomia nivosa (Montagu, 1803)	8					1		1	1	0,023
Odostomia truncatula Jeffreys, 1850	8						2	2	1	0,046
Odostomia plicata (Montagu, 1803)	8					1	1	2	2	0,046
Odostomia turrita Hanley, 1844	8					4		4	1	0,093
Odostomia unidentata (Mont., 1803)	8					13		13	1	0,30
Brachystomia scalaris (Mcgilliv.,1843)	8			1		4		5	2	0,12
Odostomia rissoides Hanley, 1844	8		14	16				30	2	0,70
Chrysalida spiralis (Montagu, 1803)	8					1		1	1	0,023
Turbonilla lactea (Linné, 1758)	8			1				1	1	0,023
Dentalium entalis Linné, 1758	8						3	3	1	0,069
Nucula sulcata Brown, 1831	8				1			1	1	0,023
Glycymeris glycymeris (Linné, 1758)	8		6	1	2			9	3	0,21
Anomia ephippium Linné, 1758	8	1	8	15				24	3	0,56
Anomia squama (Gmelin, 1791)	8						2	2	1	0,046
Pododesmus squamula (Linné, 1758)	8					1	2	3	2	0,069
Modiolus modiolus (Linné, 1758)	8		1					1	1	0,023
Modiolus barbatus (Linné, 1758)	8					1		1	1	0,023
Musculus discors (Linné, 1758)	8			1				1	1	0,023
Musculus niger (Gray, 1824)	8				1			1	1	0,023
Ostrea edulis Linné, 1758	8	2		1				3	2	0,069
Chlamys varia (Linné, 1758)	8			4				4	1	0,093
Delectopecten vitreus (Gmelin,1789)	8			2			2	4	2	0,093
Lima sp.	8						3	3	1	0,069

TABLE I: Species and frequencies (continued)

SPECIES	Class	Frequency of specimens						Total number of specimens	Absolute frequency	Relative frequency in %
		31	32	33	34	35	36			
Astarte sulcata (Da Costa, 1778)	8		1					1	1	0,023
Astarte sp.	8						1	1	1	0,023
Goodalia triangularis (Montagu,1803)	8		2		5		2	9	3	0,21
Kellia suborbicularis (Montagu, 1803)	8		2					2	1	0,076
Arculus sykesi (Chaster, 1894)	8						1	1	1	0,023
Montacuta ferruginosa (Montagu, 1803)	8			20	2	4	7	33	4	0,77
Mysella bidentata (Montagu, 1803)	8	10	23	168	7	122	125	455	6	10,56
Venerupis senegalensis (Gmelin, 1791)	8			2		1	2	5	3	0,12
Petricola pholadiformis Lamarck, 1818	8	1		58	7	55	56	177	5	4,11
Donax vittatus (Da Costa, 1778)	8	11	53	47	152	92	73	428	6	9,93
Tellina tenuis (Da Costa, 1778)	8			1		1		2	2	0,046
Tellina fabula Gmelin, 1791	8			4	1	2		7	3	0,16
Abra alba (W.Wood, 1802)	8	14	8	72	198	162	54	508	6	11,79
Abra prismatica (Montagu, 1808)	8					1		1	1	0,023
Solen marginatus Montagu, 1803	8				1			1	1	0,023
Mactra coralina (Linné, 1758)	8		1	13		1	6	21	4	0,49
Spisula elliptica (Brown, 1827)	8	1	4		5	3	1	14	5	0,32
Spisula solida (Linné, 1758)	8	17	2	7	17	4	3	50	1	1,16
Spisula subtruncata (Da Costa, 1778)	8		19	43	1	30	7	100	5	2,32
Saxicavella jeffreysi Winckworth, 1930	8						1	1	1	0,023
Pholas dactylus Linné, 1758	8			1				1	1	0,023
Barnea candida (Linné, 1758)	8	3		8	5	4	2	22	5	0,51
Zirfaea crispata (Linné, 1758)	8			3		4	1	8	3	0,19
Total class	**8**	**63**	**150**	**498**	**409**	**562**	**379**	**2061**		**47,83**
Grand totals		280	217	1224	451	1019	1118	4309		100,00
Number of species in each sample		15	23	39	22	55	43	93		

	Km 31 1976	Km 31 1977	Km 32 1977	Km 33 1977	Km 34 1977	Km 35 1977	Km 36 1977	Km 36 1976
Km 31 1976		0.78057	0.82212	0.67980	0.83254	0.71435	0.70368	0.78819
Km 31 1977	0.55951		0.81241	0.52975	0.83392	0.60313	0.58535	0.75124
Km 32 1977	0.56226	0.48762		0.64409	0.87121	0.69850	0.68242	0.81172
Km 33 1977	0.43592	0.31047	0.29602		0.71238	0.51263	0.50116	0.62894
Km 34 1977	0.62630	0.63418	0.64255	0.47009		0.74929	0.73721	0,82754
Km 35 1977	0.46538	0.35583	0.34435	0.26664	0.50493		0.55302	0.67439
Km 36 1977	0.5045	0.44226	0.43854	0.34827	0.54258	0.37528		0.66144
Km 36 1976	0.61675	0.61805	0.62437	0.47298	0.67076	0.50485	0.53961	

TABLE II: C-values (comparison of the stations two by two). The superior right part gives the species approach whereas the inferior left side gives the class approach.

km 31 32	km 32 33	km 33 34	km 34 35	km 35 36
3.2000	7.11111	8.75757	26.56097	3.27272

TABLE III: C-values (comparison of neighbour stations two by two)

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Type Specimens of Molluscs described by

G. Fischer von WALDHEIM in 1807.

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ABSTRACT. The retained type specimens of 41 species of Molluscs, described by G. Fischer von Waldheim in 1807, stored in the collections of the Zoological Museum of Moscow State University (Russia), are illustrated (the vast majority for the first time). Brief taxonomic notes are provided for each species, as well as the original descriptions.

G. Fischer von Waldheim (1771-1853) was the first director of the Museum of Moscow Imperior University. He was invited to Russia from Maintz in 1804 specially for inventory of the collections of the private museum of Paul Demidoff (1738 - 1821). These collections were donated to the Cabinet of Natural History (now Zoological Museum of Moscow State University) in 1804; they contained nearly all groups of animals, as well as minerals and coin collections. In 1806-1807 G.Fischer von Waldheim published three volumes of the catalogue of the "Museum-Demidoff". In the third volume of the catalogue (1807) G.Fischer described approximately 2500 specimens of about 830 molluscan species. Among them 103 species were described as new.

During the occupation of Moscow by the troops of Napoleon in 1812 the collections were mostly destroyed by fire, while only molluscs and "polyps" were evacuated to Vladimir and Nizhni Novgorod cities and these were returned to Moscow after the war.

The first inventory of the collections after the evacuation was made in 1871. It revealed that only about 15% of the mollusc collection survived. Later on these specimens were dispersed among the general collection of molluscs. The authors searched the entire collection of shells in the Zoological Museum and found about 90% of the molluscs of the Demidoff collection recorded during the inventory of 1871. A check-list of these molluscs has been recently published (IVANOV & KANTOR, 1991).

Basically, the shells from the P.Demidoff collection are in good condition. A few of the shells were polished. The specimens were supplied with the labels approximately 5 x 6 cm. Moreover, the catalogue number (in accordance with the numeration in the Fischer's catalogue; specimens were numbered separately in each genus), printed on a small piece of paper 4 x 6 mm, was glued to the shells. Some of the specimens were attributed to the collection on the basis of subsequently written labels, marked as "Demidoff".

The majority of type specimens were also lost in 1812 (60 species) and two type specimens were lost after 1872. Thus, type

specimens of 41 species are currently stored in the collections of Zoological Museum. The majority of the type specimens were never figured. Only the type specimens of Conidae and Xenophoridae have been illustrated (KOHN, 1981; PONDER, 1983). Many of the valid species have been forgotten and the names were never used after Fischer. In this connection the aim of the present paper is to illustrate the type specimens.

In some cases it was difficult to identify which species were described by Fischer as new due to the lack of uniformity for designation of the new species. Thus, Fischer usually designated the new species by the word mihi (my - Latin) or either by only the letter m., or by one or two asterisks. At the same time the transfer of the species from one genus into another was designated in the same way. However, in the latter case the author usually cited the original description or included synonyms. Some Fisher's new species were distinguished by the absence of any reference to previous works and the presence of a diagnosis for the species.

The authors of the present work cannot consider themselves as experts in all the groups studied by G.Fischer. That is why we do not make decisions on the systematic position of several species. This can be done more successfully by the specialists in respective groups.

Each species is provided with a copy of the original description in original spelling and brief taxonomic remarks.

The following abbreviations are used in the text:

D - the diameter of the shell

H - the shell height

L - the shell length

MD - "Museum Demidoff", vol. 3 (1807)

W - the shell width

ZMMU - Zoological Museum of Moscow State University

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Classis GASTROPODA

Family Fissurellidae Fleming, 1822

Patella dubloradiata Fischer, 1807

(Plate 1, Figs. 6,7)

MD No. 88-90.

Original description: "* Patelle double-rayon, ovale, blanche, des rayons élevés nombreux noires avec des intermédiaires plus courts rouges-pourpre." (p. 118-119).

Patella dublo-radiata, testa ovali, alba, costis numerosis elevatis nigris, intermediis brevioribus purpurascentibus.

Subdescription: "Le sommet est blanc ceinturé de brun, le dedans blanc, le fond est noir et blanc de sorte que le noir imite assez bien le contour d'une tête d'idole d'Egypte. L'une a 1 pouce de longueur sur 10 de largeur, l'autre a 8 lignes de long sur 8 de large. Num patella notata Lin?" (p. 119).

Locality: Unknown.

ZMMU No.: L-1072.

Measurements: specimen without number - L = 26.6, W = 22.2, H = 10.2 mm; specimen No. 89 - L = 17.8, W = 14.2, H = 7.3 mm.

Remarks: Junior synonym of *Clypidina notata* (L., 1758) (determined by D. Lindberg). Two syntypes retained - one specimen without number and specimen No. 89. The latter (Plate 1, Fig. 6) is designated here as lectotype. Original label lost.

Family Patellidae Rafinesque, 1815

Patella bifida Fischer, 1807.

(Plate 1, Fig. 1)

MD No. 11.

Original description: "* Patelle bifide, ovale, blanche à bandes oranges, à sommet élevé à côtes rapprochées bases; les côtes du bord allongées comprimées, bifides.

Patella bifida mihi.

Elle a 1 p.6 l. de longueur fur 1 p. 2 l. de largeur sans les epines" (p. 114).

Locality: Unknown.

ZMMU No.: L-1063.

Measurements: L = 51.4 (with spines), W = 41.1 (with spines), H = 19.0 mm.

Remarks: The species seems to be a junior synonym of *Patella barbara* L., 1758 (D. Lindberg, personal communication). Specimen has no number on the shell, original label lost. The specimen should be considered as holotype.

Patella digitata Fischer, 1807.

(Plate 2, Figs. 1,2)

MD No. 13.

Original description: "* La digite, brune, rayée de blanc, à 11 côtes élevées arrondies, dépassant de beaucoup les bords.

Patella digitata, m.

Elle est à l'intérieur blanche nacrée, bordée de brun." (p. 115).

Locality: Unknown.

ZMMU No.: L-1075.

Measurements: L = 48.6, W = 42.3, H = 9.6 mm.

Remarks: Probable senior synonym of *Patella longicosta* Lamarck, 1819. Original label lost. The specimen should be considered as holotype.

Patella rubrocostata Fischer, 1807

(Plate 1, Figs. 4,5)

MD No. 85-87.

Original description: "* Patelle à côtes rouges, ovale, peu convexe jaune, bordée de brun, à 16 côtes rouges.

Patella rubro-costata, testa ovali, subconvexa, flava, badio maculata, costis sedecim elevatis rubris.

Le dedans est rouge rose, rayé de brun aux bords, le fond est blanc, comme le sommet; elle a 10 lignes de longueur sur 8 de largeur." (p. 118).

Subdescription: "86. 87. * Patelles à côtes rouges deux variétés par l'élévation et le nombre des côtes."(p. 118).

Locality: Unknown.

ZMMU No.: L-1074.

Measurements: No. 86 - L = 21.6, W = 16.8, H = 8.0 mm; No. 87 - L= 22.6, W = 17.1, H = 9.05 mm.

Remarks: Specimen No. 85 lost. Two syntypes (MD No. 86, 87) retained. Specimen No. 86 (Plate 1, Fig. 5) is designated here as lectotype. We did not come to the final decision on the taxonomic position of the species. D. Lindberg stated that the specimens belong to *Cellana capensis* (Gmelin, 1791); although that opinion was rejected by D.Herbert and R.Kilburn, while W.Ponder suggested that it is a synonym of *Cellana ornata* Dillwyn, 1817. *P. rubrocostata* may also be a senior synonym of *Patella piperata* Gould, 1846.

Patella septemradiata Fischer, 1807

(Plate 1, Fig. 3)

MD No. 15.

Original description: "* P. à 7 rayons, anguleuse avec sept côtes rayées transversalement.

Patella septem-radiata, m.

Cette patelle est blanche-jaunâtre, bigarré de brun. Le sommet et les bords sont d'un brun uniforme. Entre les rayons principaux se trouvent cinq ou six cordons élevés d'un blanc nacré." (p. 115).

Locality: Unknown.

ZMMU No.: L-1069.

Measurements: L = 26.6, W = 23.0, H = 4.5 mm.

Remarks: The species was determined as *Patella longicosta* Lamarck, 1819 (thus being the senior synonym of it) by D.Lindberg. The specimen should be considered the holotype.

Patella spinosa Fischer,1807

(Plate 1, Fig. 2)

MD No. 14.

Original description: "* L'épineuse, blanche, à sommet et à rayons oranges, à 12 côtes élevées très tranchantes, depassant de beaucoup les bords avec des pointes tranchantes.

Patella spinosa, m." (p. 115).

Locality: None.

ZMMU No.: L-1040.

Measurements: L = 39.5 (with spines), W = 38.0 (with spines), H = 8.9 mm.

Remarks: Original label lost. The name is a primary junior homonym of *Patella spinosa* Gmelin, 1791. The specimen should be considered as holotype. We did not come to the final decision on the taxonomic position of the species. D. Lindberg identified the specimen as *Patella longicosta* Lamarck, 1819, while R.Kilburn identified it as *Patella barbara* L., 1758. D.Herbert stated that it can be a distinct species.

Patella novemradiata Fischer, 1807

(Plate 2, Fig. 7)

MD No. 93, 94.

Original description: "* Patelle à neuf rayons, ovale, bleuâtre, à neuf rayons élevés blancs.

Patella novem-radiata, testa ovali, tenui, pellucida caerulea, costata, novem costis albis.

Le sommet est bas et jaune, entouré de blanc, le fond à l'intérieur est brun, le reste est bleuâtre avec des stries jaunes." (p. 119).

Locality: None.

ZMMU No.: L-1057.

Measurements: L = 28.0, W = 23.6, H = 9.0 mm.

Remarks: Probably junior synonym of *Cellana radians* (Gmelin, 1791) (determined by D.Lindberg). The name is a primary senior homonym of *Patella novemradiata* Quoy et Gaimard, 1834. The single specimen without number retained and was designated as lectotype (IVANOV & KANTOR, 1991). Original label lost.

Family Turbinidae Rafinesque, 1815

Solarium radiatum Fischer,1807

(Plate 3, Figs. 6,7)

MD No. 4-8.

Original description: "Cadran solaire, convexe, les tours de spire radiés par des larges épines, L'ombilic finement plissé.

Solarium radiatum, mihi. - *Trochus solaris* Lin. Mus. Lud. Ulr. 645. n. 328. Bosc. 4. 152. - Chemnitz. 5.1.173. f. 1700, 1701. t. 174. f. 1716, 1717... L'un des plus grand contient une trés petite écrevisse bernard." (p. 214).

Locality: "Mer des Indes".

ZMMU No.: L-479.

Measurements: H = 59.0, D = 91.3 mm.

Remarks: Junior synonym of *Astraea heliotropium* (Martyn, 1784) = imperialis (Gmelin, 1791). A single specimen without number was retained and was designated as the lectotype (IVANOV & KANTOR,, 1991). Original label lost.

Family Cypraeidae Rafinesque, 1815

Cypraea albopunctata Fischer, 1807

(Plate 4, Fig. 7,8)

MD No. 93-96.

Original description: "* Porcelaine à points blancs, Jaunâtre, mince, parsemée de points blancs, dont quelques uns sont annelés de brun, une ligne longitudinale blanchâtre.

Cypraea albo-punctata, mihi.

C'est la même coquille que Martini a figurée dans son ouvrage 1. p. 393. t. 30. 323. et décrite sous le nom de: weisse Frieselporcellane; quelques auteurs l'ont considérée comme une simple variété de l'erosée, mais elle forme une espèce distincte, 1. par les bords plus renflés et garnis de traits bruns, 2. par sa forme plus alongée, 3. par son dessin, les taches annelées, s'il y en a, sont blanches et entourées de brun, une raie blanchâtre suit la direction de la columelle et deux grandes taches violettes se trouvent des deux côtés." (p. 153).

Subdescription: "96. Porcelaine à points blanches, variété singulière à raie longitudinale courbée en forme de lettre S." (p. 153).

Locality: None.

ZMMU No.: L-559.

Measurements: specimen without number - H = 34.3, D = 23.0 mm; specimen No. 96 - H = 30.5, D = 20.0 mm.

Remarks: Junior synonym of *Cypraea erosa* L., 1758. Two syntypes retained - one

specimen without number and specimen No. 96. The latter (Plate 4, Fig. 8) is designated here as lectotype.

Cypraea lunata Fischer, 1807

(Plate 4, Fig. 6)

MD No. 97-98.

Original description: "* Porcelaine lunelée, alongée, jaunâtre, parsemée de taches blanches en forme de croissant.

Cypraea lunata mihi, testa elongata, lutescente, maculis albis lunatis obducta.

Cette porcelaine qui par sa belle forme et sa beauté rivalise avec beaucoup d'autres, est nouvelle. Elle est petite, d'un pouce, deux lignes, de longueur, sur huit lignes de largeur, alongée, mince, jaune foncé, garni de petites taches blanches en forme de demi-lunes. La ligne longitudinale qui separe le dos fait aussi distinction du dessin. L'autre moitié près de la lèvre renflée est blanche et garnie de points fauves. La lèvre elle - même porte des points imprimés bruns. Le dessous est jaune pointillé de brun." (p. 153-154).

Locality: None.

ZMMU No.: L-528.

Measurements: H = 27.0, D = 18.8 mm.

Remarks: Junior synonym of *Cypraea acicularis* Gmelin, 1791. The single specimen without number retained and was designated as lectotype (IVANOV & KANTOR, 1991).

Family Ovulidae Fleming, 1828

Ovula papyracea Fischer, 1807

(Plate 5, Fig. 7)

MD No. 2.

Original description: "* Ovule papyracée, Ovale, prolongée des deux cotés, la lèvre droite mince, transparente et tranchante.

Ovula papyracea, testa ovata birostri; labro tenui, acuto.

Cette belle coquille présente la même blancheur que l'ovule oeuf, mais elle est plus petite, très mince et transparente. La lèvre est plus écartée, et des deux cotés sont plus alongés que dans l'ovule oeuf." (p. 156).

Locality: Unknown.

ZMMU No.: L-600.

Measurements: H = 75.0, D = 43.7 mm.

Remarks: Junior synonym of *Ovula ovum* (L., 1758). The single juvenile specimen should be considered as holotype.

Ovula dentata Fischer, 1807

(Plate 5, Figs. 8,9)

MD No. 13, 14.

Original description: "* Ovule dentée, Ovale; les prolongements très courts, étant le produit du renflement de la lèvre, dont le bord est très épais et finement dentée.

Ovula dentata mihi, testa ovata, margine interius et exterius incrassato, arcte denticulato. Cette ovule est plus petite que toutes les autres, elle n'a que 7 lignes de longueur sur 4 de largeur. Elle est très gibbeuse, à dos très élevé, et a des prolongements très courts, qui sont entièrement produits par le renflement de la lèvre, qui a un bord très gros et finement dentelé. Les deux exemplaires que nous possédons sont rouges, couleur de chair, l'une passant au violet; les prolongements sont intérieurement rouges de cinnabre." (p. 157-158).

Locality: Unknown.

ZMMU No.: L-597.

Measurements: H = 13.0, D = 7.6 mm.

Remarks: Probably a junior synonym of *Pseudosimnia carnea* (Poiret, 1789). The single specimen No. 14 retained and was designated as lectotype (IVANOV & KANTOR, 1991).

Family Calyptraeidae Lamarck, 1809

Calyptraea inaequalis Fischer in Kantor & Ivanov, 1991.

(Plate 6, Figs. 1,2)

MD No. 4, 5.

Original description: "Calyptrée inégale ou chiffonnée, irrégulière, à bord sinueux à surface rugueux, à languette partant librement du centre.

Deux exemplaires; dont l'une plus grande, blanche, transparente. Rare et sans doute une espèce distincte." (p. 128).

Locality: None.

ZMMU No.: L-103.

Measurements: L = 40.3, W = 36.5, H = 19.5 mm.

Remarks: We were not able to find any name, under which the species (probably belonging to *Cheilea*) is cited in recent literature. In the original description Fisher did not give the Latin name. The name *inaequalis* was on the label, which was written probably in 1872. Therefore the name was validated and the single retained specimen without number was designated as lectotype by IVANOV & KANTOR (1991). Original label lost.

Calyptraea imbricata Fischer, 1807

(Plate 6, Fig. 5,6)

MD No. 6,7.

Original description: "Calyptrée à étages, blanche, à quatre ou plusieurs réplis feuilletés par étages. La languette centrale courte et mince.

Calyptrea imbricata mihi.

Linné en a fait une variété de la Clochette (Mus. Reg. Ulr. p. 687. n. 408. *Patella labiata equestris* a) lamellis horizontalibus imbricatis.) Mais elle doit former une espèce distincte parcequ'elle n'a rien de commun avec la clochette que les caractères génériques. C'est une des plus rares coquilles. V. Martini. I. 155. t. 13 f. 125. 126. Nos deux exemplaires sont parfaitement bien conservés; l'un, plus grand, à quatre étages plus distantes; l'autre, plus petit, en a six qui sont ondulées." (p. 128).

Locality: None.

ZMMU No.: L-96.

Measurements: L = 14.6, W = 8.0, H = 7.6 mm.

Remarks: Probably a synonym of *Cheilea tectumsinense* (Lamarck). The single preserved specimen No. 6 was designated as lectotype (IVANOV & KANTOR, 1991).

Crepidula holiotoidea Fischer, 1807.

(Plate 6, Figs. 3,4)

MD No. 6,7.

Original description: "* C. haliotoïde, ovale, aplatie, à sommet latéral et couché (comme dans les haliotides) à côtes élevées et granuleuses, à cloison sillonnée.

Crepidula holiotoidea, testa subovali, vertice laterali depresso, striis elevatis granulatis divergentibus, labio sulcato.

Cette coquille est très rare, et point d'auteur n'en a fait mention. Elle s'approche par la forme génerale des haliotides, mais la cloison intérieure la range parmi les crepidules. Cette cloison est sillonnée et échancrée sur le bord. Elle a dix lignes de longueur sur 8 de largeur." (p. 127).

Locality: Unknown.

ZMMU No.: L-81.

Measurements: H = 16.2, D = 19.0 mm.

Remarks: A senior synonym of *Crepidula dilatata* Lamarck, 1822. The single preserved specimen No. 7 was designated as lectotype (IVANOV & KANTOR, 1991). Original label lost. The name "*holiotoidea*" in the Latin diagnoses is undoubtedly misspelled. Nevertheless, we decided to keep with this spelling in order to avoid homonymy with *Crepidula haliotoidea* Marwick, 1926.

Family Xenophoridae Philippi, 1856

Xenophora tricostata Fischer, 1807

(Plate 5, Figs. 1-3)

MD No. 2,3.

Original description: "* Xenophore à trois côtes, turriculée, garnie de coquilles, trois côtes distinctes sortant de l'ombilic.

Xenophora tricostata mihi - *Trochus conchyliophorus aliorum*. L'un des individus porte des sabots, les ouvertures tournées vers le sommet, et des opercules; l'autre des bivalves, il est grand et bien conservé." (p. 213).

Locality: None.

ZMMU No.: L-77.

Measurements: H = 50.0, D = 53.2 mm.

Remarks: Junior synonym of *Xenophora cochliophora* (Born, 1780) (PONDER, 1983). The single preserved specimen without number was designated by Ponder as "holotype". The specimen should be considered as lectotype in accordance with MCZN, article 74.

Xenophora mecandrina Fischer, 1807

(Plate 5, Figs. 4-6)

MD No. 6.

Original description: "* Xenophore méandrine, subturriculée, les tours de spire garnis de méandrines, la base à côtes nombreuses ne laissant point d'espace entre elles.

Xenophora mecandrina mihi. Je trouve les côtes de la base variables et cependant concordantes dans des especes semblables, voici pourquoi j'en ai tiré le caractere spécifique, mais je ne dois cependant pas dissimuler, que les côtes varient d'après la quantité d'objêts étrangers qui garnissent le premier tour de la coquille. Elles paroissent être les conduits des vaisseaux ou au moins les endroits ou sont attachés les vaisseaux conducteurs du liquide calcaire lequel colle ces différents objêts." (p. 214).

Locality: None.

ZMMU No.: L-78.

Measurements: H = 31.0, D = 47.0 mm.

Remarks: Junior synonym of *Xenophora cochliophora* (Born, 1780) (PONDER, 1983). The single preserved specimen without number was designated as lectotype (IVANOV & KANTOR, 1991).

Family Strombidae Rafinesque, 1815

Strombus tricornis Fischer, 1807

(Plate 3, Fig. 2)

MD No. 29.

Original description: "Str. tricorne, la lèvre très alongée, avec une pointe plissé en avant, le dos couronné de trois épines.

Strombus tricornis mihi. Vulgairement: le cocu, der dreyeckige braun-roth geflammte Kampfhahn. Der gehörnte Fecher. Grande ailée de la Jamaïque, Davila Cat. syst. p. 183. p. 317. Cochlis alata monodactyles Martini. 3. p. 140. tb. 84. f. 843. - 845." (p. 188).

Locality: "mer des Indes".

ZMMU No.: L-730.

Measurements: H = 64.8, D = 47.2 mm.

Remarks: Junior synonym and junior primary homonym of *Strombus tricornis* Lightfoot, 1786. The specimen should be considered as holotype.

Strombus sulcatus Fischer, 1807

(Plate 3, Figs. 1,4-5)

MD No. 27, 28.

Original description: "Strombe sillonné, la lèvre alongée renflée sur le bord avec une pointe arrondie en avant, le dos sillonné, à sillons élevés dont deux à tubercules, spire alongée, tuberculée.

Strombus sulcatus mihi." (p. 188).

Locality: None.

ZMMU No.: L-718.

Measurements: 2 specimens: H = 76.6 and 60.0, D = 56.6 and 42.5 mm respectively.

Remarks: Junior synonym of *Strombus raninus* Gmelin, 1791. Two syntypes without numbers retained. The larger specimen (Plate 3, Fig. 1) is designated here as lectotype.

Family Ranellidae Gray, 1854

Cassidea tuberculata Fischer, 1807

(Plate 7, Fig. 4)

MD No. 23-25.

Original description: "Casque tuberculeux, ovale, ondulé de sillons transverse, quatre côtes, et les bords de spire garnis de tubercules obtus.

Cassidea tuberculata mihi." (p. 185).

Locality: Unknown.

ZMMU No.: L-518.

Measurements: H = 61.6, D = 38.4 mm.

Remarks: Junior synonym of *Argobuccinum pustulosum* (Lightfoot, 1786). The single retained specimen without number was designated as lectotype (IVANOV & KANTOR, 1991).

Family Muricidae Rafinesque, 1815

Murex tricostatus Fischer, 1807.

(Plate 7, Fig. 1)

MD No. 114, 115.

Original description: "Rocher à trois côtes, triangulaire à trois sillons longitudinaux très

gros, striés transversalement, la lèvre droite crenelée.

Murex tricostatus mihi. Il appartient plutôt à la division précendente, et doit occuper sa place à coté de *Murex alatus* et *triqueter*, quoiqu'il est beaucoup plus grand et très pesant. Voici pourquoi Martini l'a appellé *Purpura triquetra ponderosa*. 3. p. 347. t. 110. f. 1029. 1030." (p. 199).

Locality: "côte de Coromandel."

ZMMU No.: L-277.

Measurements: H = 73.0, D = 57.0 mm.

Remarks: Probably senior synonym of *Hexaplex kuesterianus* (Tapparone-Canefri, 1875), or a separate species. The single preserved specimen No. 114 was designated as lectotype (IVANOV & KANTOR, 1991).

Murex alatus Fischer, 1807

(Plate 7, Figs. 5,6)

MD No. 29.

Original description: " * R. ailé, blanc, strié transversalement avec trois rangées de feuilles epineuses, les épines creuses et ailées.

Murex alatus mihi. Les feuilles erigées, aussi minces comme du papier, et frangées ou crénelées le long de la queue, enveloppent du coté droit les épines, de sorte que les épines en deviennent ailées. - Elle resemble au rocher triptère par la crête et par la grandeur, mais elle en diffère par les épines creuses, par sa delicatesse, ou que je m'exprime ainsi, par sa nature papyracée, et enfin parcequ'elle ne se trouve pas fossile. - Il paroit que Martini a voulu présenter la même coquille. 3. t. 111. f. 1034. 1035. mais la figure n'est pas reconaissable. La déscription en est un peu plus claire, on y trouve au moins ces épines canaliculées et ailées d'un coté qui rendent cette coquile si remarquable." (p. 194-195).

Locality: Unknown.

ZMMU No.: L-308.

Measurements: H = 49.2, D = 27.6 mm.

Remarks: Probably senior synonym of *Pterynotys acanthopterus* (Lamarck, 1816), or a separate species. The name appeared to be junior homonym of *Murex alatus* Gmelin, 1791 (Turridae) (VOKES, 1971). The specimen should be considered as holotype.

Acanthina imbricata Fischer, 1807

(Plate 4, Figs. 2,5)

MD No. 1,2.

Original description: "La licorne tuilée, brune, les côtes inégales, garnies d'écailles tuilées; la lèvre droite crenelée.

Acanthina imbricata m. *Buccinum monodon*, Pallas Spicil. 10. p. 33. t. 3. f. 3. 4. - Des bonnes figures. Voy. Knorr. IV. t. 30. f. 1. Regenfuss T. 2. ib. 7. f. 2. Martyn's Univ. Conchol. T. 1. f. 10. T. 2. f. 50. Bucc.Calcar; - Chemnitz, 10. t. 154. f. 1469. 1470. - des parages magellaniques. - Bosc dans son ouvrage d'ailleurs très estimé fait double adhibition de la licorne tuilée. Une fois elle représente *Buccinum monoceros* Voy T. 4. p. 268; une autre fois *Purpura monodon*, Tom. 5. p. 27." (p. 174-175).

Locality: "des parages magellaniques."

ZMMU No.: L-335.

Measurements: Two specimens - H = 58.2, D = 38.0 (No. 1), H = 63.8, D = 44.4 (without number) mm.

Remarks: Synonym of *Acanthina monodon* (Pallas, 1774) and senior homonym of *Acanthina imbricata* Lamarck, 1816. Two syntypes retained: (No. 1) and a specimen without number. The specimen No. 1 (Plate 4, Fig. 2) is designated here as lectotype.

Acanthina costata Fischer, 1807

(Plate 4, Fig. 1)

MD No. 4-6.

Original description: " La licorne à côtes, jaunâtre, les côtes inégales, les plus élevées tranchantes, la lèvre droite plissée en dedans.

Acanthina costasta mihi. *Buccinum narhval* Bosc. 45. 268." (p. 175).

Locality: None.

ZMMU No.: L-354.

Measurements: H = 58.6, D = 41.8 mm.

Remarks: A synonym of the highly variable *Acanthina monodon* (Pallas, 1774). The name "*costasta*" in the original description is misspelled and was corrected to "*costata*"

according to label (IVANOV & KANTOR, 1991). Original label lost. The single retained specimen is designated here as lectotype (not holotype, as published in IVANOV & KANTOR, 1991).

Acanthina laevigata Fischer, 1807

(Plate 4, Fig. 3)

MD No. 7,8.

Original description: "La licorne lisse, lisse et à côtes oblitérés, la lèvre droite lisse, l'épine très longue et visible le long de la lèvre droite.

Acanthina laevigata mihi." (p. 175).

Locality: None.

ZMMU No.: L-370.

Measurements: H = 42.2, D = 30.6 mm.

Remarks: Probably a synonym of *Acanthina monodon* (Pallas, 1774). The single retained specimen is designated here as lectotype.

Family Buccinidae Rafinesque, 1815

Eburna chemnitziana Fischer, 1807

(Plate 7, Fig. 8)

MD No. 4.

Original description: "Eburne de Chemnitz, ombiliquée, lisse, blanche, tachetée de brun ou de pourpre, les tours de spire distincts mais arrondis.

Eburna Chemnitziana mihi. Linné regardoit cette belle coquille comme une variété de la précédente [*Eburna spirata*]. Mais elle en diffère totalement par les caractères énoncés dans la description et surtout par l'ombilique non denté. Chemnitz l'a pris le premier pour une espèce distincte. 4. t. 122. f. 1120 1121." (p. 178).

Locality: "côtes de la Chine et des Isles voisines", "Ceylon" on original label.

ZMMU No.: L-360.

Measurements: H = 59.0, D = 37.7 mm.

Remarks: Synonym of *Babylonia areolata* (Link, 1807). We were unable to ascertain the exact date of publication of both original description and thus the name of Fischer may be either junior, or senior synonym of *Babylonia areolata* (Link, 1807). The specimen should be considered as holotype.

Buccinum fasciatum Fischer, 1807

(Plate 3, Fig. 3)

MD No. 6.

Original description: "* Buccin rubanné, oblongue presque fusiforme, brun, à fascies transversales plus foncées, dont deux regulièrement tachetées de blanc.

Buccinum fasciatum mihi. Les taches blanches triangulaires et en forme de fleche, qui imite un peu la barbe d'une plume a sans doute produit le nom de Hahnenfeder, *Buccinum pennatum* de Martini. 4. t. 127. f. 1218-20." (p. 177).

Locality: "côtes de Jamaiques et de l'Ascension", "Jamaique" on the original label.

ZMMU No.: L-412.

Measurements: H = 35.7, D = 15.5 mm.

Remarks: Junior synonym of *Pisania pusio* (L., 1758). The specimen should be considered as holotype.

Family Fasciolariidae Gray, 1853

Buccinum agathinum Fischer, 1807

(Plate 4, Fig. 4)

MD No. 4,5.

Original description: "* Buccin porcelaine, oblongue, très épaisse, blanche, à stries circulaires brunes et très étroitement placées, la bouche très blanche.

Buccinum agathinum mihi. - Der braungestreiste Bauernjunge Martini. 3. t. 120. f. 1104. 1105. Vulgairement la bouche de lait." (p. 177).

Locality: "Indes orientales".

ZMMU No. L-403.

Measurements: H = 48.8, D = 28.0 mm.

Remarks: Junior synonym of *Latiralagena smaragdula* (L., 1758). Single retained specimen without number was designated as lectotype (IVANOV & KANTOR, 1991).

Family Vexillidae Thiele, 1929

Mitra turriculata Fischer, 1807

(Plate 7, Fig. 3)

MD No. 28.

Original description: "* Mitre turriculée, emarginée, sillonnée longitudinalement, à sillons écartés, striés transversalement, la columelle à trois plis.

Mitra turriculata, testa turrita emarginata, longitudinaliter sulcata, costis distantibis, transversim striata, columella triplicata.

Une très belle mitre jaune à tours de spire bordés de brun foible. Les côtes qui garnissent toute la coquille, sont larges et très écartées, un peu courbée au milieu." (p. 171).

Locality: None.

ZMMU No.: L-434.

Measurements: H = 42.0, D = 14.0 mm.

Remarks: Probably junior synonym of *Vexillum vulpecula* (L., 1758). The single retained specimen without number was designated as lectotype (IVANOV & KANTOR, 1991). Original label lost.

Family Olividae Latreille, 1825

Oliva fusca Fischer, 1807.

(Plate 8, Figs. 1-7)

MD No. 19-89.

Original description: " L'olive nègre, unie; la base de la spire recourbée, la columelle obliquement striée.

Oliva fusca m.

Voluta oliva Lin. Gm. 3439. 17. Bosc. 5. 37. Martini. 2. t. 45. f. 472. 473. Knorr. 5. t. 28. f. 6." (p. 160).

Subdescription: "On considère comme variétés de L'Olive nègre:

21. l'Olive à robe brune plus claire avec des raies transversales plus foncées.

22 - 25. l'Olive à robe brun-clair passant au rouge ou au jaune.

26. l'Olive à robe brune avec une bande ou zone, au milieu, tachetée de noir.

29. l'Olive blanchâtre avec des taches irrégulières couleur d'olive.

30. l'Olive verdâtre avec des dessins en zigzag.

58 - 59. [should be up to No. 82] Suite d'Olives dont les dessins en zigzag forment des zones réticulées; 15 individus." (p. 160-161).

Locality: "mer des Indes".

ZMMU No.: L-447.

Measurements: lectotype - H = 52.6, D = 27.2 mm.

Remarks: Specimens No. 19 and No. 20 were lost. 24 specimens retained: specimens No. 21, 22, 26, 29, 30, 59, and 18 specimens without numbers. All of them were considered by Fischer as a varieties of *Oliva fusca*. Specimen No. 21 was designated as lectotype (IVANOV & KANTOR, 1991). Thus the species appears to be junior synonym of *Oliva vidua* Roeding, 1798 (Bernard Tursch, personal communication). Original label lost. On the present label of later origin locality was marked as "Espagnie", probably erroneously. The name *Oliva fusca* Fischer is to be either junior, or senior homonym of *Oliva fusca* Link, 1807 (see remarks under *Eburna chemnitziana* Fischer, 1807).

Other specimens should be considered as paralectotypes and belong to different species: No. 22 (Plate 8, Fig. 2) and 26 (Plate 8, Fig. 7) - to *Oliva vidua* Roeding, 1798; No. 29 (Plate 8, Fig. 3) - *Oliva (Viduoliva)* sp.; No. 30 (Plate 8, Fig. 5) - *Oliva* cf. *elegans* Lamarck, 1811; No. 59 (Plate 8, Fig. 4) - *Oliva* cf. *tremulina* Lamarck, 1811; specimens without numbers - *Oliva vidua* Roeding, 1798 (Plate 8, Fig. 6); *Oliva annulata* Gmelin, 1791; *Oliva bifasciata* Küster, 1877; *Oliva fumosa* Marat, 1871; *Oliva* spp.

Oliva elongata Fischer, 1807

(Plate 8, Fig. 8)

MD No. 136-143.

Original description: " Olive alongée, Alongée, à spire très longue à lévres distantes.

Oliva elongata.

Gmelin a considéré cette olive comme une variété de l'Utricule, (Martini 2. t. 50. f. 549 - 554.) mais à ce qu'il me paroit, elle doit former une espèce distincte, vu sa proportion alongée et cylindrique; l'autre étant ventrue." (p. 162-163).

Locality: None.

ZMMU No.: L-450.

Measurements: H = 63.2, D = 23.0 mm.

Remarks: Probably senior synonym of *Agaronia nebulosa* (Lamarck, 1811). The single retained specimen without number was designated as lectotype (IVANOV & KANTOR, 1991).

Family Conidae Rafinesque, 1815
Conus caracteristicus Fischer, 1807

(Plate 7, Fig. 7)

MD No. 113-116.

Original description: "Cône caractéristique, conique, blanc, avec des tâches brunes en forme de caractères placés en trois séries, spire aplatie, mucronée.

Conus caracteristicus, testa conica, alba, characteribus rufescentibus in triplici fascia inscriptis, spira truncata obtusissima, alba, ex fusco maculata, basi striis exoratis cincta. Chemnitz. 10. p. 54. t. 182. f. 1760. 1761." (p. 139).

Subdescription: "116. Variété rare à spire tout à fait tronquée, à fascies intermediaires blanches non ponctuées."

Locality: None.

ZMMU No.: L-615.

Measurements: H = 44.8, D = 28.5 mm.

Remarks: Valid species. The single specimen No. 116 retained. This specimen was considered by Fischer as only a variety of his *Conus caracteristicus* and belongs to *Conus eburneus* Hwass, 1792. This allowed Kohn (1981) to designate the cited figures in Chemnitz (1788: pl. 182, fig. 1760, 1761) as lectotype. The mentioned figures represented a specimen of undescribed species. Therefore the retained specimen No. 116 should be considered as a paralectotype.

Conus fusiformis Fischer, 1807

(Plate 7, Fig. 2)

MD No. 179-180.

Original description: "* Cône fusiforme, rouge-rouse avec des stries élevées et des fascies blanches, la spire obtuse.

Conus fusifornis [sic!], testa subconica, transversim striata fasciis duabus albis.

Ce cône doit former une espece nouvelle qui se distingue des autres cônes tarrières par le corps peu ventru, par la spire plus obtuse que dans les autres et par sa grandeur. L'un des deux individus que nous possedons, a deux pouces cinq lignes de longueur, sur 1 pouce de largeur. Je l'ai reçu sous le nom de bout de chandelle." (p. 144).

Locality: Unknown.

ZMMU No.: L-608.

Measurements: H = 44.5, D = 19.0 mm.

Remarks: Junior synonym of *Conus glans* Hwass, 1792. The single retained specimen No. 179 was designated as lectotype (KOHN, 1981). Kohn corrected an inadvertent error in "*fusifornis*" in diagnosis to "*fusiformis*".

Subclassis Divasibranchia Minichev et Starobogatov, 1975
Family Siphonariidae Gray, 1840
Patella serrata Fischer, 1807

(Plate 2, Figs. 3-6)

MD No. 25,26.

Original description: " Patelle scie, presque ronde, à côtes nombreuses élevées et dentelées en forme de scie.

Patella serrata mihi, testa sub-rotunda, costis multi elevatis serratis.

Deux exemplaires dont l'une est verte et rouge, rayée de blanc à l'intérieur, l'autre blanche et jaune.

Elles n'ont que 8 lignes de longueur sur 6 de largeur, et paraissent avoir quelque analogie avec la radiée, *Patella alboradiata* de Bosc. 3. 198." (p. 116).

Locality: None.

ZMMU No.: L-1076.

Measurements: L = 19.0, W = 14.7, H = 5.9 (No. 25) and L = 17.0, W = 15.2, H = 5.6 (No. 26) mm.

Remarks: We were not able to find any name, under which the species is cited in recent literature. The species belongs to *Siphonaria*. Two syntypes retained, both with the numbers. Original label lost. Specimen No. 25 is designated here as lectotype.

***Patella leucogramma* Fischer, 1807.**
(Plate 1, fig. 8)
MD No. 24.

Original description: "* Patelle leucogramme, ovale à sommet pointu, bleu d'indigo et presque central, à 12 côtes élevées blanches.

Patella leucogramma, mihi.

Testa ovali tenui, striis elevatis albis undecim, vertice mucronato azureo. La patrie en est inconnue. Le dedans est bleu d'indigo au fond qui est ceinturé de brun. Ce n'est que le bord qui présente à l'intérieur des raies blanches. Cette belle patelle a 9 lignes de longueur sur 7 de largeur." (p. 115-116).

Locality: Unknown.

ZMMU No.: L-1044.

Measurements: L = 21.6, W = 15.5, H = 7.9 mm.

Remarks: We were not able to find any name, under which the species is cited in recent literature. The species belongs to *Siphonaria* (D.Lindberg, personal communication). The specimen should be considered as holotype.

Classis BIVALVIA
Family Mytilidae Rafinesque, 1815
***Mytilus variabilis* Fischer, 1807**
(Plate 9, Figs. 7-10)
MD No. 48,49.

Original description: "Moule variable, oblongue, pyramidale, transparente, transversalement striée, à stries concentriques, une bosse variable.

Mytilus variabilis mihi. Cette moule est transparente, bleu-noirâtre, et a une singulière conformation de ses deux valves. L'une a une bosse alongée auprès de la charnière, l'autre auprès des bords. Celle-ci forme comme une bouche hiante pour faire sortir le byssus par lequel l'animal s'attache. Cette ouverture des bords est-elle peut-être le caractère d'un genre particulier dont nous ne connaissons que cette espèce. - Elle fait en tout cas le passage aux modioles de Lamarck; et n'a rien de commun avec la moule azurée de Gmelin." (p. 249).

Locality: None.

ZMMU No.: L-2193.

Measurements: L = 53.2 mm.

Remarks: Probably a junior synonym of *Mytilus edulis* L., 1758. The single retained specimen No. 49 was designated as lectotype (IVANOV & KANTOR, 1991). Original label lost.

***Modiola rufa* Fischer, 1807**
(Plate 9, Figs. 1-6)
MD No. 6.

Original description: " Modiole rouge, lisse, mince, transparente, rouge-clair.

Modiola rufa mihi. Est ce la moule rouge de Bosc? la nôtre n'est pas rugueuse." (p. 250).

Locality: None.

ZMMU No.: L-2170.

Measurements: L = 71.6 and 68.5 mm, respectively.

Remarks: The species belongs to *Modiolus*, and similar to *Modiolus neglectus* Soot-Ryen, 1955. Two syntypes without numbers and polished surface retained. One of them is probably later addition. According to very similar condition and polished valves, the second specimen was added by Fischer himself after the publication of MD. The larger (Plate 9, Figs. 1-4) is designated here as lectotype. Original label lost.

Family Lucinidae Fleming, 1928
***Lucina reticulata* Fischer, 1807**
(Plate 6, Figs. 7-10)
MD No. 12-14.

Original description: "Lucine rezeau.

Lucina reticulata mihi; - *Venus tigerina*, Lin. Dargenville. t. 21. f E. Adanson t. 16. f. 3. le Codock; = Knorr. Del. 4. t. 14. f. 4. Chemnitz. 7. p. 6. t. 37. f. 390. 391. Bosc. 3. 60. pl. 19. f. 3. Vulgairement: rezeau blanc; langue de tigre." (p. 261).

Locality: None.

ZMMU No.: Ld-1664.

Measurements: L = 44.4, W = 43.2 mm.

Remarks: The species belongs to *Codakia*. The only retained specimen without number

was designated as lectotype (IVANOV & KANTOR, 1991). Original label lost.

Class POLYPLACOPHORA
Family Chitonidae Rafinesque, 1815
Chiton undulatus Fischer, 1807

(Plate 2, Fig. 8)

MD No. 7,8.

Original description: "* l'Oscabrion ondulé, à huit valves lisses brunes, à stries transversales, ondulées jaunes.

Chiton undulatus, testa octovalvi laevi brunnea, striis transversalibus undulatis flavis.

Les deux exemplaires paroissent apartenir à la même espèce quoique l'une soit un peu plus grande et même plus pâle en couleurs. Les stries transversales se sont plus près au milieu de la quatrième et cinquième valve; là elles imitent des flammes. La ligne du milieu qui fait le centre ou le sommet est grisâtre accompagné d'une bordure brune-foncée. Le ligament circulaire est garni de petites écailles alongées grises et vertes. Les écailles ou valves principales sont intérieurement dentélées et d'un vert très pâle.

L'une a 1. p. 5. l. de largeur, sur 10. l. de longueur et l'autre 1. p. 3. l. de large, sur 9 de long." (p. 112).

Locality: None.

ZMMU No.: L-1026.

Measurements: L = 32 mm.

Remarks: Junior synonym of *Chiton marmoratus* Gmelin, 1791. The single retained specimen No. 8 was designated as lectotype (IVANOV & KANTOR, 1991). Original label lost.

Chiton bipunctatus Fischer, 1807

(Plate 2, Fig. 9)

MD No. 5.

Original description: "* L'oscabrion deux-points, à huit valves ridées, les valves terminales sillonnées, les intermédiaires garnies de coté et par devant de trois points élevés.

Chiton bipunctatus, testa octovalvi rugosa, terminalibus sulcatis, intermediis latere margineuque anteriore bipunctatis.

Cette espèce d'Oscabrion, couverte d'une croute calcaire, sans être fossile, est nouvelle. Elle est de la grandeur de la précedente; ses écailles sont ridées, les terminales sillonnées; les sillons sortent d'un centre commun et se terminent avant le contour dans un bourrelet élevé. Les écailles intermédiaires présentent auprès de leur sommet qui se termine en épine élevée, deux points noirs et à la marge opposée, de coté, trois points noirs élevés. L'intérieur est d'un vert très foncé. Les contours sont blancs, garnis d'écailles grisâtres en forme de lentilles.

Le port total le distingue de l'Oscabrion tacheté de Chemnitz 8. t. 95. f. 802. 2. p. 2. 1. de longueur, 1. p. 11. de largeur." (p. 111-112).

Locality: Unknown.

ZMMU No.: L-1022.

Measurements: L = 58.2 mm.

Remarks: Junior synonym of *Chiton squamosus* L., 1764. Original label lost. The specimen should be considered as holotype (not lectotype, as designated in IVANOV & KANTOR, 1991).

Chiton incompletus Fischer, 1807

(Plate 2, Fig. 10)

MD No. 9.

Original description: "* l'Oscabrion incomplet, à huit valves blanches jaunâtres qui ne touchent pas le contour ligamenteux.

Chiton incompletus, testa octovalvi laevi, ligamentum circulare non attingente.

Cet oscabrion a 1 p. 2 l. de largeur sur 8 l. de longueur. Les valves sont partout bordées d'un large contour membraneux où on ne voit point de traces des écailles latérales qui laissent toujours des impressions plus ou moins profondes. Les valves elles-mêmes sont jaunes avec des lignes concentrique violettes pâles. Le sommet forme une ligne élevée brune à trois sillons bien profonds des deux cotés. Les deux valves terminales sont rayonnées, à rayons divergens formés par des points, bruns

et imprimés. On trouve de pareils rayons sur les valves intermédiaires qui partent du sommet vers le contour. L'intérieur est blanc-rougeâtre et les valves sont un peu découpées au milieu." (p. 113).

Locality: None.

ZMMU No.: L-1028.

Measurements: L = 29 mm.

Remarks: Senior synonym of *Tonicia atrata* (Sowerby, 1840). Original label lost. The specimen should be considered as holotype.

Below is the list of species (in the original transcription), described by Fischer, type specimens of which have not been located and are assumed to have been lost. Numeration of specimens is in accordance with MD.

Chiton
6 * - *striatus*
Patella
10 - *undecim-costata* mihi
107* - *maculata*
Galerita
9 * - *punctata* mihi
Calyptrea
12 * - *verrucosa* mihi
Conus
25,26* - *rare*
41 - *roseus*
42 - *citrinus* mihi
50,51 - *porcellaneus*
123-125* - *gigas*
173,174* - *alatus*
Cypraea
36,37 - *Ferruginea*
Oliva
90-92 - *plicata* mihi
133 - *guttata* mihi
Ancilla
2 - *coccinea* mihi
3-6 - *laevigata* mihi
7,8 - *bullata* mihi
Voluta
27 - *citrina* mihi
Marginella
4-6 - *glauca* mihi
7,8* - *ventricosa* m.
Cancellaria
9-11 - *mitroides* mihi
Nassa
3* - *granulata* mihi
4,5* - *laevis* m.
Terebra
22* - *undata* mihi
28* - *ammiralis*, mihi
31,32 - *oblongo-guttata* mihi
Cassidea
14* - *punctata* mihi
15* - *plicata* mihi
Strombus
62-65 - *spinosus* mihi
66 - *tuberculatus* mihi
Murex
107 - *imperialis* mihi
Fasciolaria
15 - *lilium* mihi
Turbinellus
1,2 - *spinosus* mihi
3,4 - *corona* mihi
15* - *flammeus* mihi
Pleurotoma
6-8 - *sulcata* mihi
Cerithium
12-13 - *variegatum* mihi
Trochus
32 - *granulatus*
Xenophora
1* - *laevigata* mihi
4,5* - *vulcanica* mihi
Monodonta
2 - *canaliculata* mihi
3 - *bicostata* mihi
4-7 - *granulata* mihi
Cyclostoma
3-5 - *fasciatum* mihi
6 - *bicinctum* mihi
Auricula
4 - *papyracea* mihi
Pleurodonte Mihi
5,6 - *inaequalis* mihi
Helix
22,23 - *dubia* mihi
Vermicularia
5 - *calyculata* mihi
Siliquaria
2 - *spinosa* mihi
3 - *turbinata* mihi

Capsa
5,6 - *costata* mihi
7,8 - *laevis* mihi
Tellina
12 - *violacea* mihi
Donax
13 - *fimbriata* mihi
Cardita
3 - *interrupta* mihi
Cardium
23,24 - *reticulatum* mihi
Arca
23 - *radiata* mihi
Alectryonia Mihi
1 - *rara* Mihi
2 - *parasitica* mihi
Ostrea
1 - *concentrica* mihi
5 - *capsa* mihi

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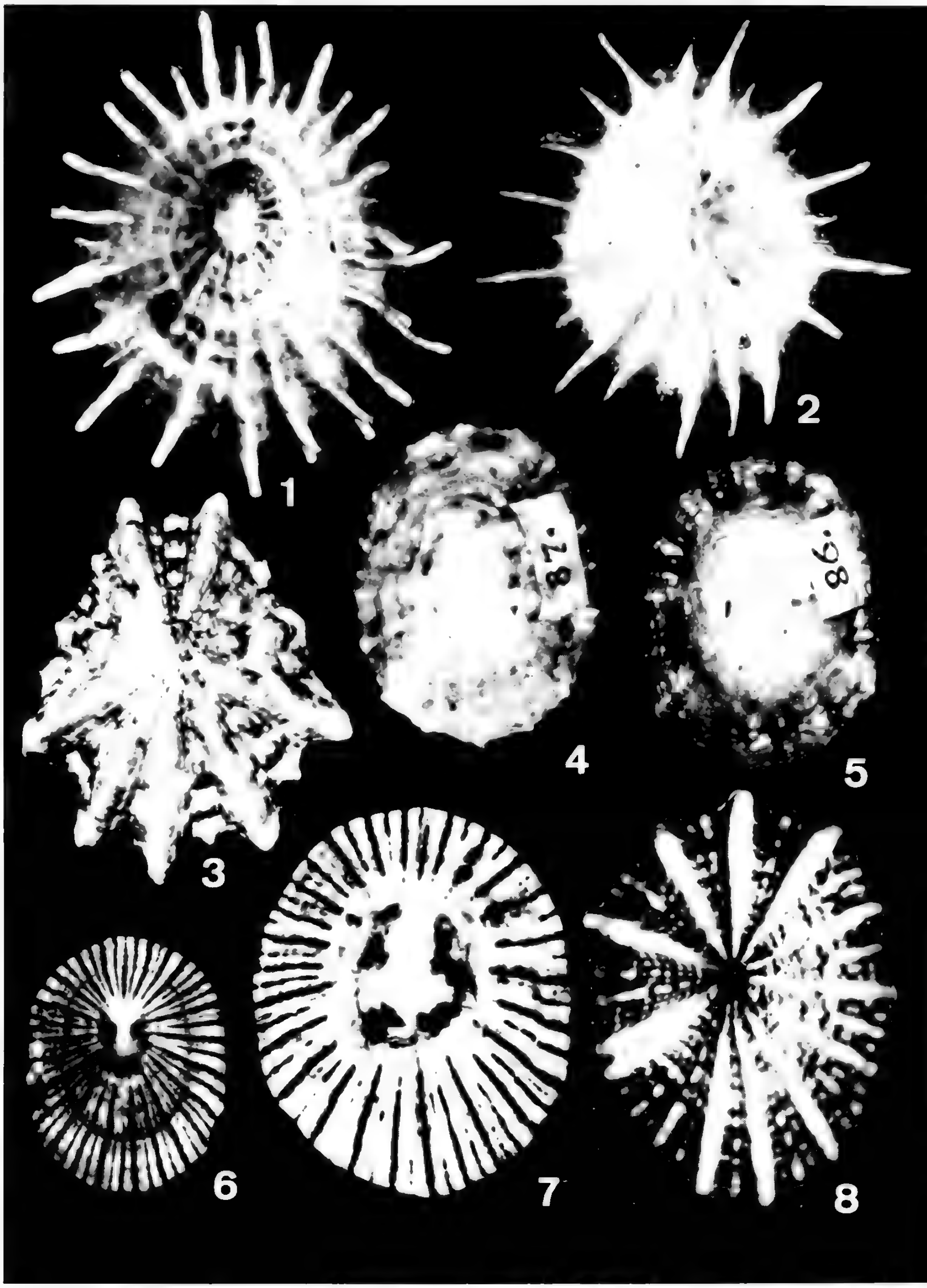

Plate 1. 1 - *Patella bifida* Fischer, 1807, holotype, L = 51.4 (with spines), W = 41.1 (with spines), H = 19.0 mm. 2 - *Patella spinosa* Fischer,1807, holotype, L = 39.5 (with spines), W = 38.0 (with spines), H = 8.9 mm. 3 - *Patella septemradiata* Fischer, 1807, holotype, L = 26.6, W = 23.0, H = 4.5 mm. 4,5 - *Patella rubrocostata* Fischer, 1807, 4 - paralectotype, L= 22.6, W = 17.1, H = 9.05 mm; 5 - lectotype, L = 21.6, W = 16.8, H = 8.0 mm. 6,7 - *Patella dubloradiata* Fischer, 1807 6 - lectotype, L = 17.8, W = 14.2, H = 7.3 mm; 7 - paralectotype, L = 26.6, W = 22.2, H = 10.2 mm. 8 - *Patella leucogramma* Fischer, 1807, holotype, L = 21.6, W = 15.5, H = 7.9 mm.

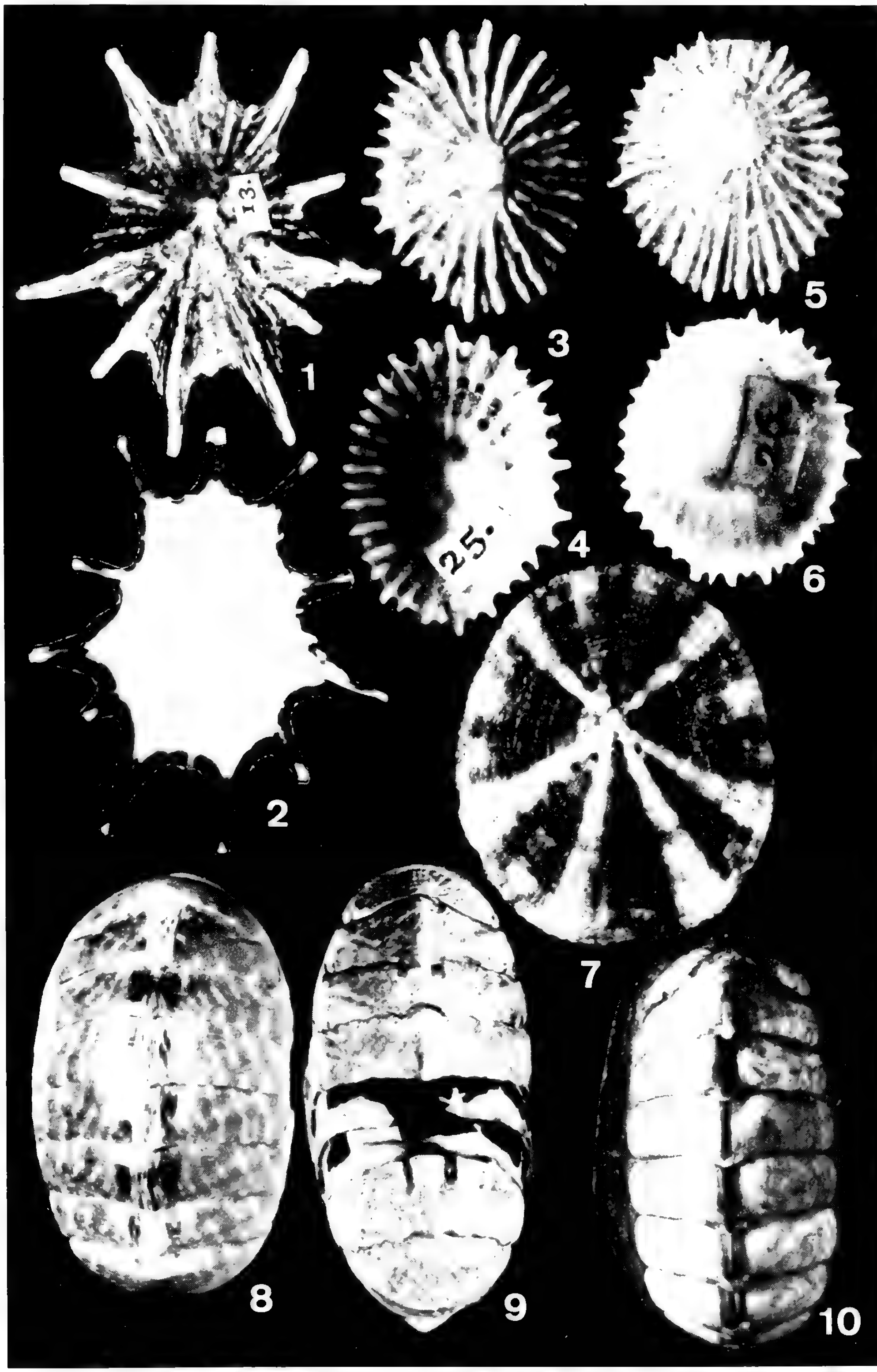

Plate 2. 1,2 - *Patella digitata* Fischer, 1807, holotype, L = 48.6, W = 42.3, H = 9.6 mm. 3-6 - *Patella serrata* Fischer, 1807; 3-4 - lectotype, L = 19.0, W = 14.7, H = 5.9 mm; 5-6 - paralectotype, L = 17.0, W = 15.2, H = 5.6 mm. 7 - *Patella novemradiata* Fischer, 1807, lectotype, L = 28.0, W = 23.6, H = 9.0 mm. 8 - *Chiton undulatus* Fischer, 1807, lectotype, L = 32 mm. 9 - *Chiton bipunctatus* Fischer, 1807, holotype, L = 58.2 mm. 10 - *Chiton incompletus* Fischer, 1807, holotype, L = 29 mm.

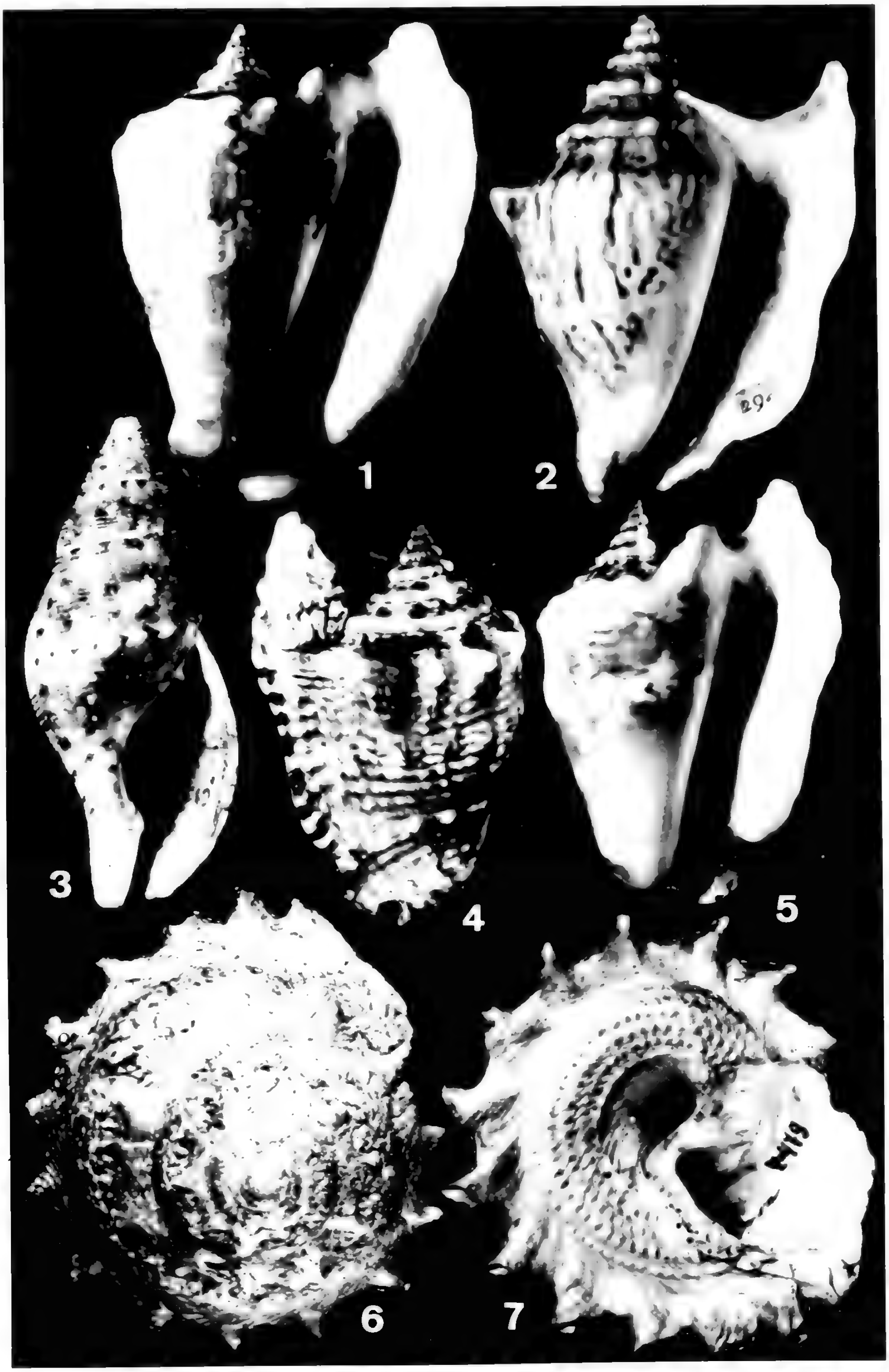

Plate 3. 1, 4,5 - *Strombus sulcatus* Fischer, 1807, 1 - lectotype, H = 76.6 , D = 56.6 mm, 4,5 - paralectotype, H = 60.0, D = 42.5 mm. 2 - *Strombus tricornis* Fischer, 1807, holotype, H = 64.8, D = 47.2 mm. 3 - *Buccinum fasciatum* Fischer, 1807, holotype, H = 35.7, D = 15.5 mm. 6,7 - *Solarium radiatum* Fischer,1807, lectotype, H = 59.0, D = 91.3 mm.

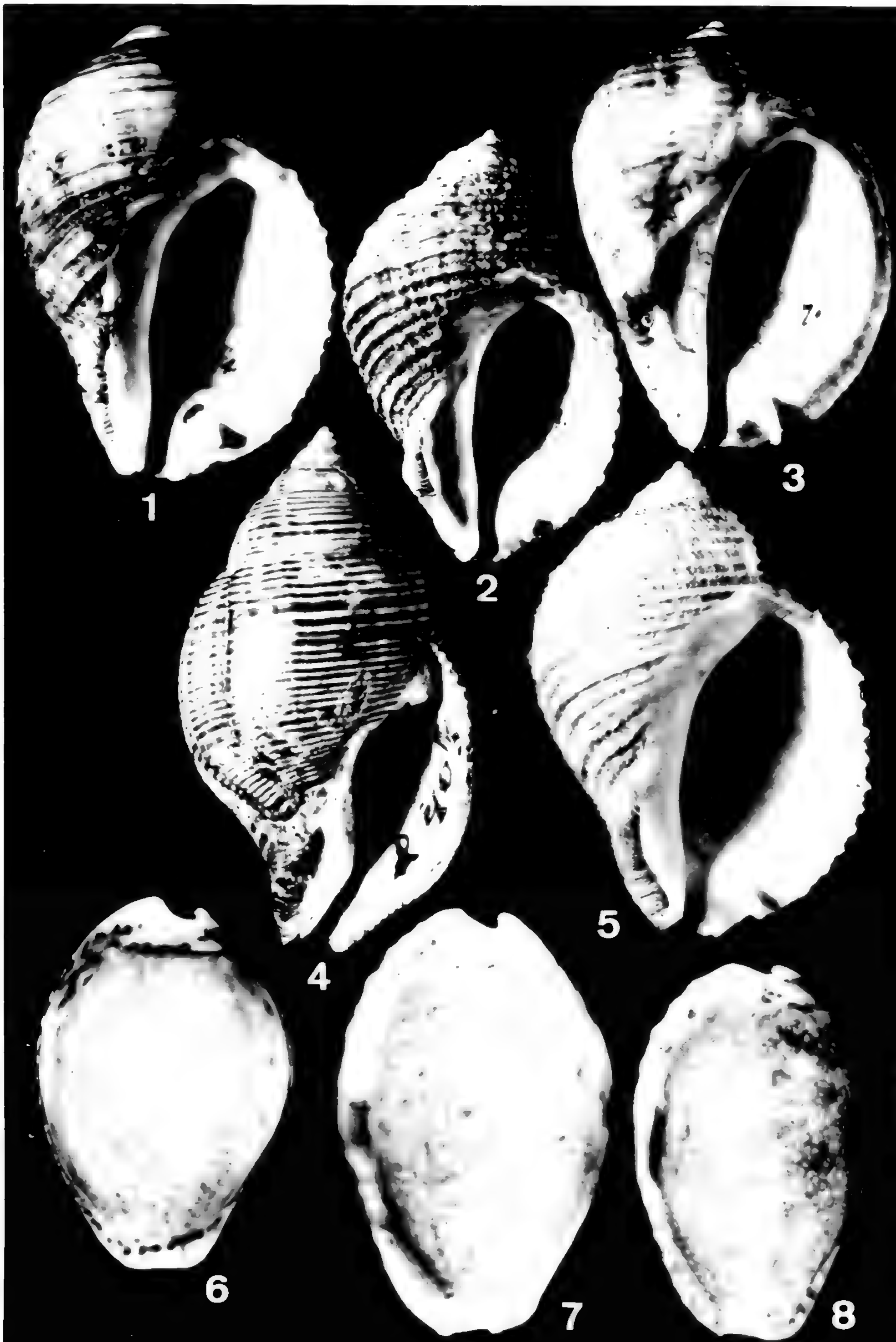

Plate 4. 1 - *Acanthina costata* Fischer, 1807, lectotype, H = 58.6, D = 41.8 mm. 2,5 - *Acanthina imbricata* Fischer, 1807, 2 - lectotype, H = 58.2, D = 38.0 mm; 5 - paralectotype, H = 63.8, D = 44.4 mm. 3 - *Acanthina laevigata* Fischer, 1807, lectotype, H = 42.2, D = 30.6 mm. 4 - *Buccinum agathinum* Fischer, 1807, lectotype, H = 48.8, D = 28.0 mm. 6 - *Cypraea lunata* Fischer, 1807, lectotype, H = 27.0, D = 18.8 mm. 7,8 - *Cypraea albopunctata* Fischer, 1807, 7 - paralectotype, H = 34.3, D = 23.0 mm; 8 - lectotype, H = 30.5, D = 20.0 mm.

Plate 5. 1-3 - *Xenophora tricostata* Fischer, 1807, lectotype, H = 50.0, D = 53.2 mm. 4-6 - *Xenophora mecandrina* Fischer, 1807, lectotype, H = 31.0, D = 47.0 mm. 7 - *Ovula papyracea* Fischer, 1807, holotype, H = 75.0, D = 43.7 mm. 8, 9 - *Ovula dentata* Fischer, 1807, lectotype, H = 13.0, D = 7.6 mm.

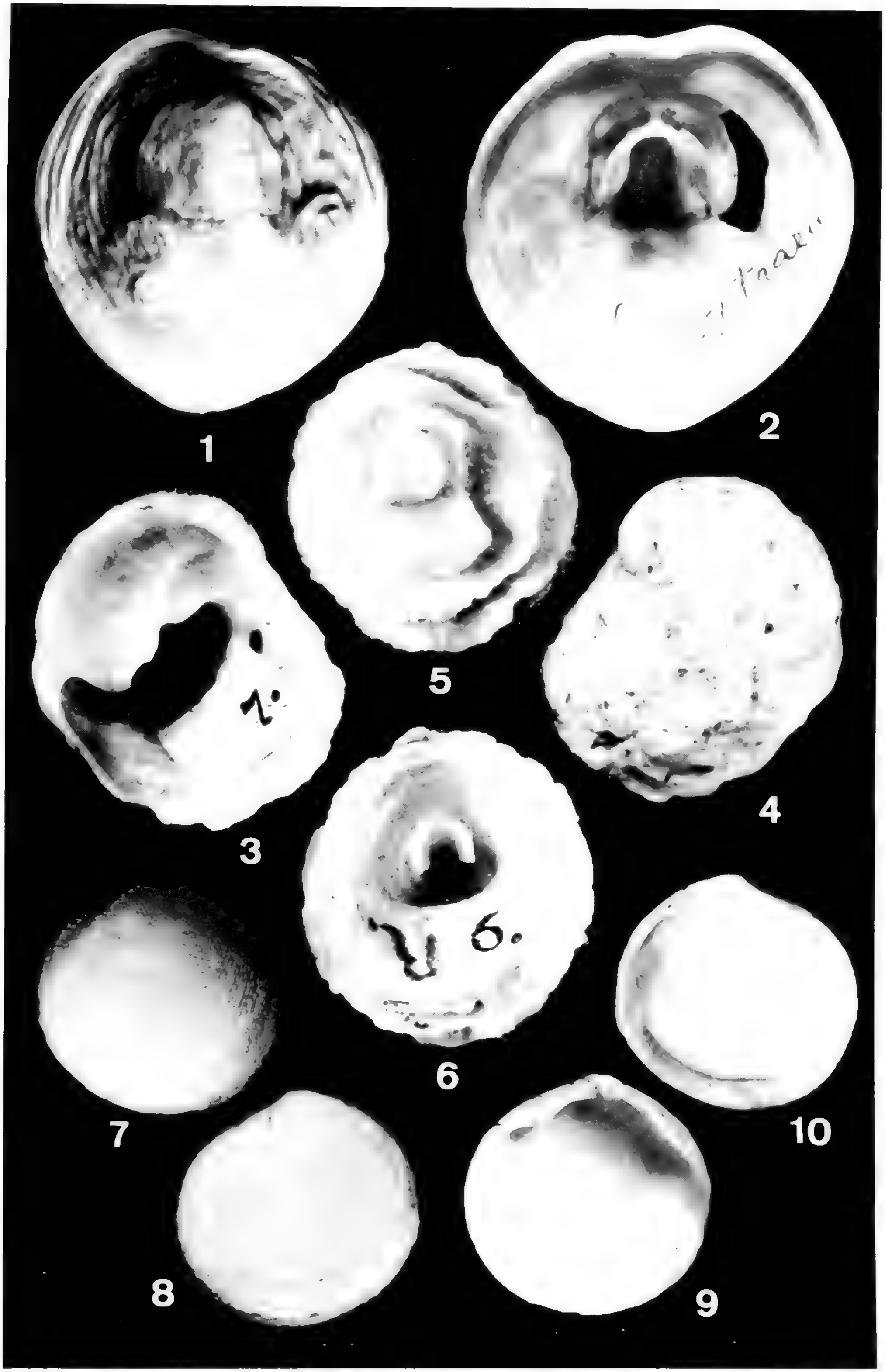

Plate 6. 1,2 - *Calyptraea inaequalis* Fischer, 1807, lectotype, L = 40.3, W = 36.5, H = 19.5 mm. 3,4 - *Crepidula holiotoidea* Fischer, 1807, lectotype, H = 16.2, D = 19.0 mm. 5,6 - *Calyptraea imbricata* Fischer, 1807, lectotype, L = 14.6, W = 8.0, H = 7.6 mm. 7-10 - *Lucina reticulata* Fischer, 1807, lectotype, L = 44.4, W = 43.2 mm.

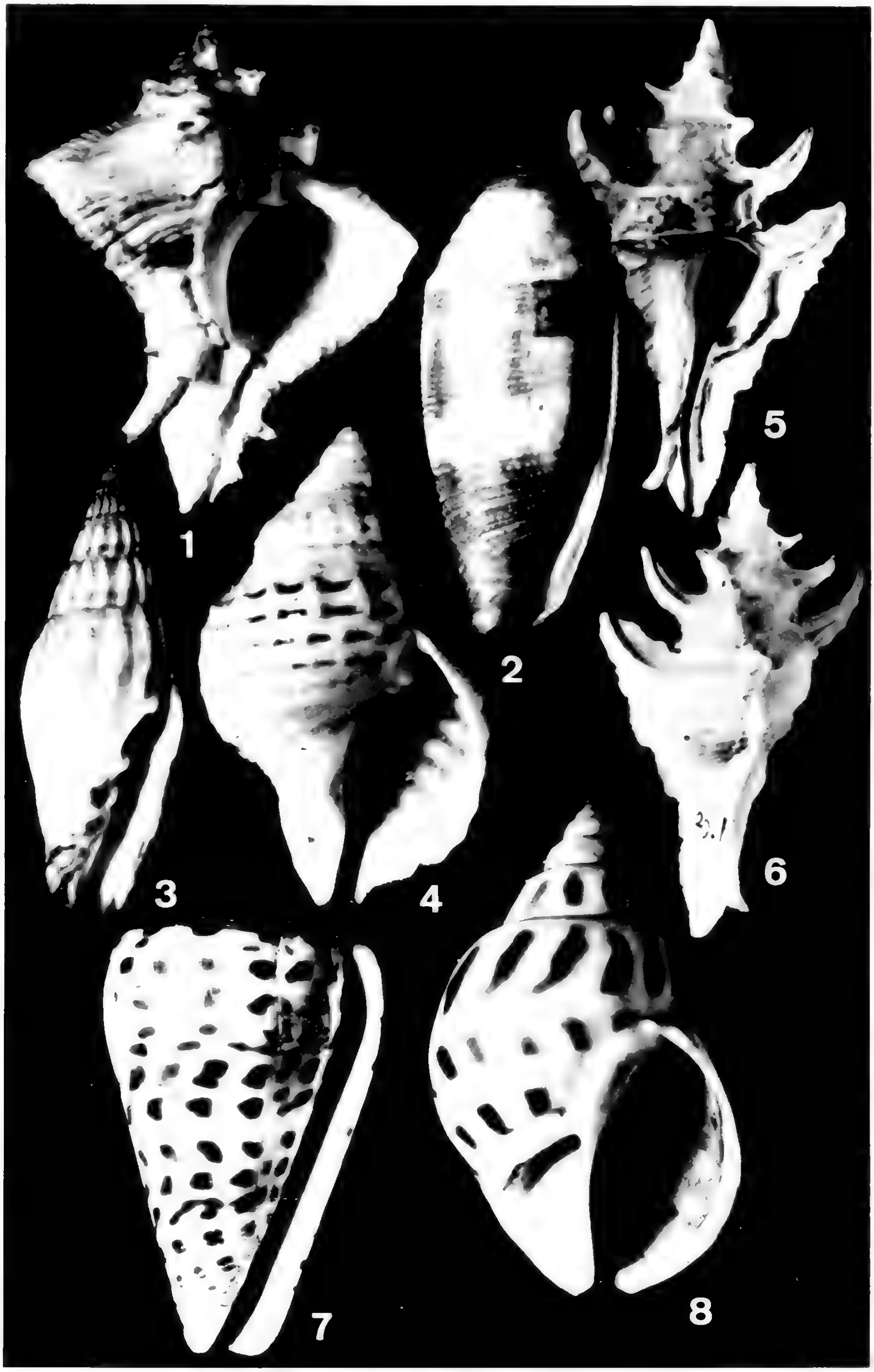

Plate 7. 1 - *Murex tricostatus* Fischer, 1807, lectotype, H = 73.0, D = 57.0 mm. 2 - *Conus fusiformis* Fischer, 1807, lectotype, H = 44.5, D = 19.0 mm. 3 - *Mitra turriculata* Fischer, 1807, lectotype, H = 42.0, D = 14.0 mm. 4 - *Cassidea tuberculata* Fischer, 1807, lectotype, H = 61.6, D = 38.4 mm. 5,6 - *Murex alatus* Fischer, 1807, holotype, H = 49.2, D = 27.6 mm. 7 - *Conus caracteristicus* Fischer, 1807, paralectotype, H = 44.8, D = 28.5 mm. 8 - *Eburna chemnitziana* Fischer, 1807, holotype, H = 59.0, D = 37.7 mm.

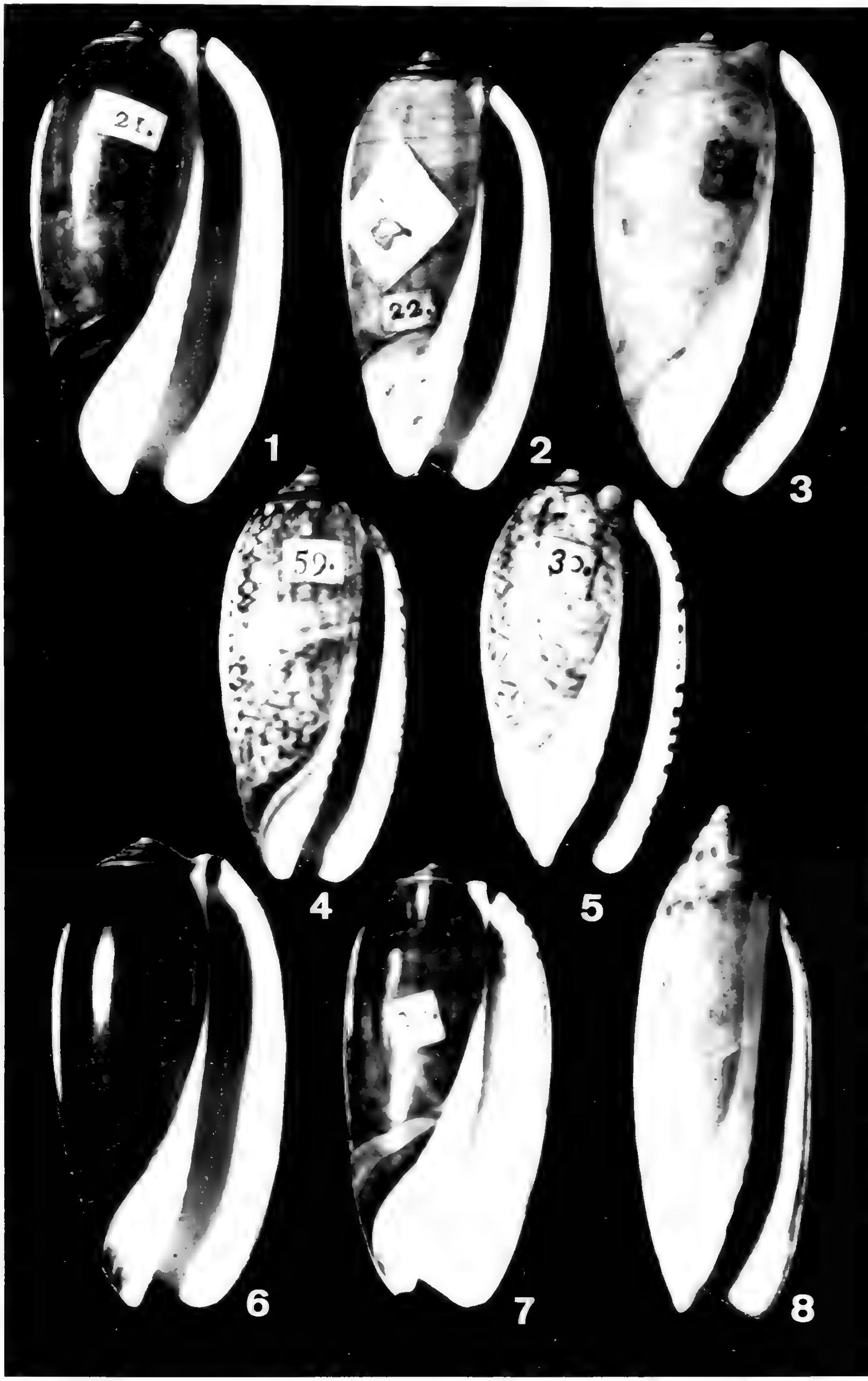

Plate 8. 1-7 - *Oliva fusca* Fischer, 1807: 1 - lectotype, H = 52.6, D = 27.2 mm; 2 - paralectotype (= *Oliva vidua* Roeding, 1798), H = 43.5 mm; 3 - paralectotype (=*Oliva* (*Viduoliva*) sp.), H = 45.1 mm; 4 - paralectotype (=*Oliva* cf. *tremulina* Lamarck, 1811), H = 40.8 mm; 5 - paralectotype (=*Oliva* cf. *elegans* Lamarck, 1811), H= 39.7 mm; 6 - paralectotype (= *Oliva vidua* Roeding, 1798), H= 59.4 mm; 7 - paralectotype (= *Oliva vidua* Roeding, 1798), H= 43.8 mm. 8 - *Oliva elongata* Fischer, 1807, lectotype, H = 63.2, D = 23.0 mm.

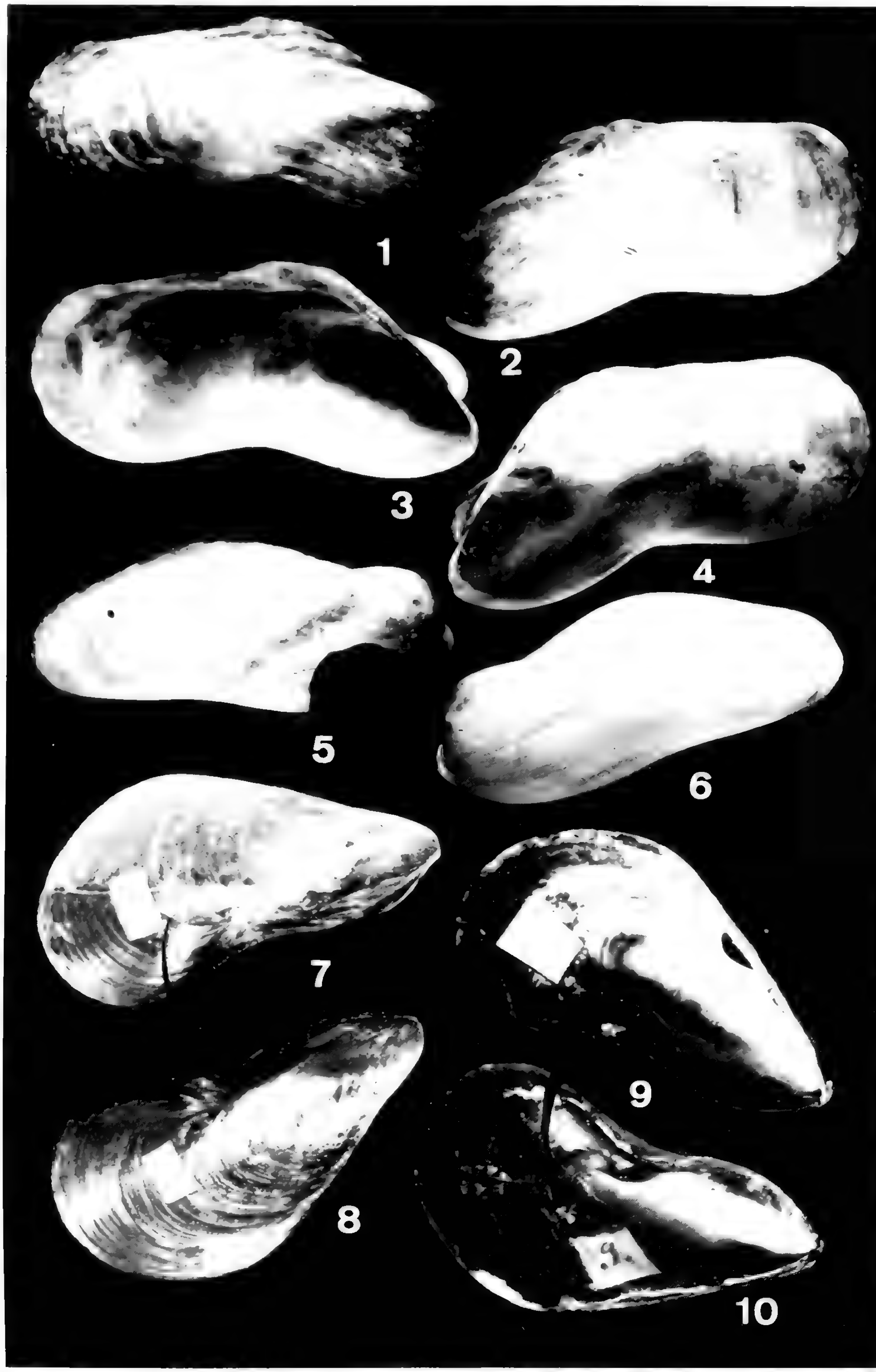

Plate 9. 1-6 - *Modiola rufa* Fischer, 1807, 1-4 - lectotype, L = 71.6 mm; 5,6 - paralectotype, L = 68.5 mm. 7-10 - *Mytilus variabilis* Fischer, 1807, lectotype, L = 53.2 mm.

The Family Triphoridae (Mollusca, Gastropoda) in Cuba.

2. The Genus *Iniforis* Jousseaume, 1884

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KEYWORDS: Mollusca, Gastropoda, Triphoridae, *Iniforis*, Cuba

ABSTRACT: The species of the genus *Iniforis* Jousseaume, 1884 (family Triphoridae) from Cuba are studied. Three new species are described, being designated a neotype for *I. turristhomae* (Holten, 1802). The protoconch, important element for specific separation, is described and illustrated for each species.

RESUMEN: Se estudia en género *Iniforis* Jousseaume, 1884 (familia Triphoridae) en la isla de Cuba. Se describen tres nuevas especies siendo designado un neotipo para *I. turrithomae* (Holten, 1802). Las protoconchas de todas las especies, elemento importante para la separación específica, son descritas y representadas.

INTRODUCTION

JOUSSEAUME (1884: 235-236) created the genus *Iniforis* with the following description: "coquille sénestre, allongée et subulée, à surface granuleuse; spire composée de plus de quinze tours; le dernier à trois ouvertures inégales". LASERON (1958: 579) comments: "Jousseaume divided the recent species with the so-called three apertures into two series: *Iniforis*, for those with two rows of gemmules and more than 15 whorls and *Mastoniaeforis* for those with three rows of gemmules and 15 whorls of less".

MARSHALL (1983: 7) considered that the genera *Mastonia* Hinds, 1843, *Iniforis* Jousseaume, 1884 and *Mastoniaeforis* Jousseaume, 1884 are related because they show a progressive development of the posterior canal from a simple notch. MARSHALL (*op. cit.*: 45), opted for maintaining *Mastonia*, *Mesophora*, *Iniforis*, and *Mastoniaeforis* as separate genera.

Material collected in Cuba through the co-operation of two Spanish Universities (Autonoma of Madrid and Oviedo) with the University of La Habana, and also material collected in other occasions by the junior author yielded a lot of species of the Family Triphoridae. The first work (ROLÁN & FERNANDEZ-GARCÉS, 1993) tried on the genus *Metaxia* Several species which could be included into the genus *Iniforis* due to the existence of three apertures and two cords per whorl, are studied in the present. The number of spire's whorls of these species were up to 15 in some of them, and fewer in some others, especially in those with a paucispiral

protoconch. They are very similar to the shells figured by LASERON (1958: 214 & 217) for the genus *Iniforis*, but also to the species placed in the genus *Epiforis* Laseron, 1958.

RESULTS

Abbreviations used:

MNCN: Museo Nacional de Ciencias Naturales, Madrid

IES: Instituto de Ecología y Sistemática, La Habana

MNHN: Museum National d'Histoire Naturelle, Paris

BMNH: The Natural History Museum, London

AMNH: American Museum of Natural History, New York

ZMA: Zoölogisch Museum, Amsterdam

CFG: R. Fernandes-Garcés, Cienfuegos, Cuba

CER: E. Rolán, Vigo, Spain

Genus *Iniforis* Jousseaume, 1884

= *Mastoniaeforis* Jousseaume, 1884
= *Epiforis* Laseron, 1958
= *Contraforis* Laseron, 1958

No important characters separate the genus *Mastoniaeforis* (and its synonyms *Epiforis* and *Contraforis*, in the opinion of MARSHALL, 1983) from *Iniforis*, because the form of the protoconch or the number of whorls are not good specific characters for generic separation.

Iniforis turristhomae (Holten, 1802)
Figs. 1, 2, 3, 4, 20, 21, 31, 32, 33, 34

Turris Thomae Chemnitz, Systematisches Conchylien-Cabinet, vol. 11, p. 310, t. 213, fig. 3022, *a* to *d*.

Turbo turris-Thomae Holten, 1802. Enumeratio systematica Conchyliorum beat. Chemnitzii, p. 71 (refers the fig. 3022 of Chemnitz).

Cerithium mirabile C. B. Adams, 1850. Contrib. Conch, 7: 118.

Material examined

More than two hundred specimens and shells collected in the following places:

North of Cuba (CER): at 4 m, in Baracoa; at 3 m, in Marina Hemingway; at 10 m, in La Herradura; at 5 m, in Jibacoa; at 3 m, in the proximity of the Hotel Comodoro, La Habana.

South of Cuba: at 1 m, in Cable Inglés and between 15 to 30 m, in Faro de los Colorados, Cienfuegos (CER y CFG); between 10 m to 17 m, in Cayo Matías, at 6 m, in Cayo Cantiles and at 8 m, in Cayo Avalos, Arquipelago of Los Canarreos (CER); at 50 m, in Punta Pedernales and between 10 to 20 m, in Punta Francés, Isla de la Juventud (CER y MNCN).

Type material

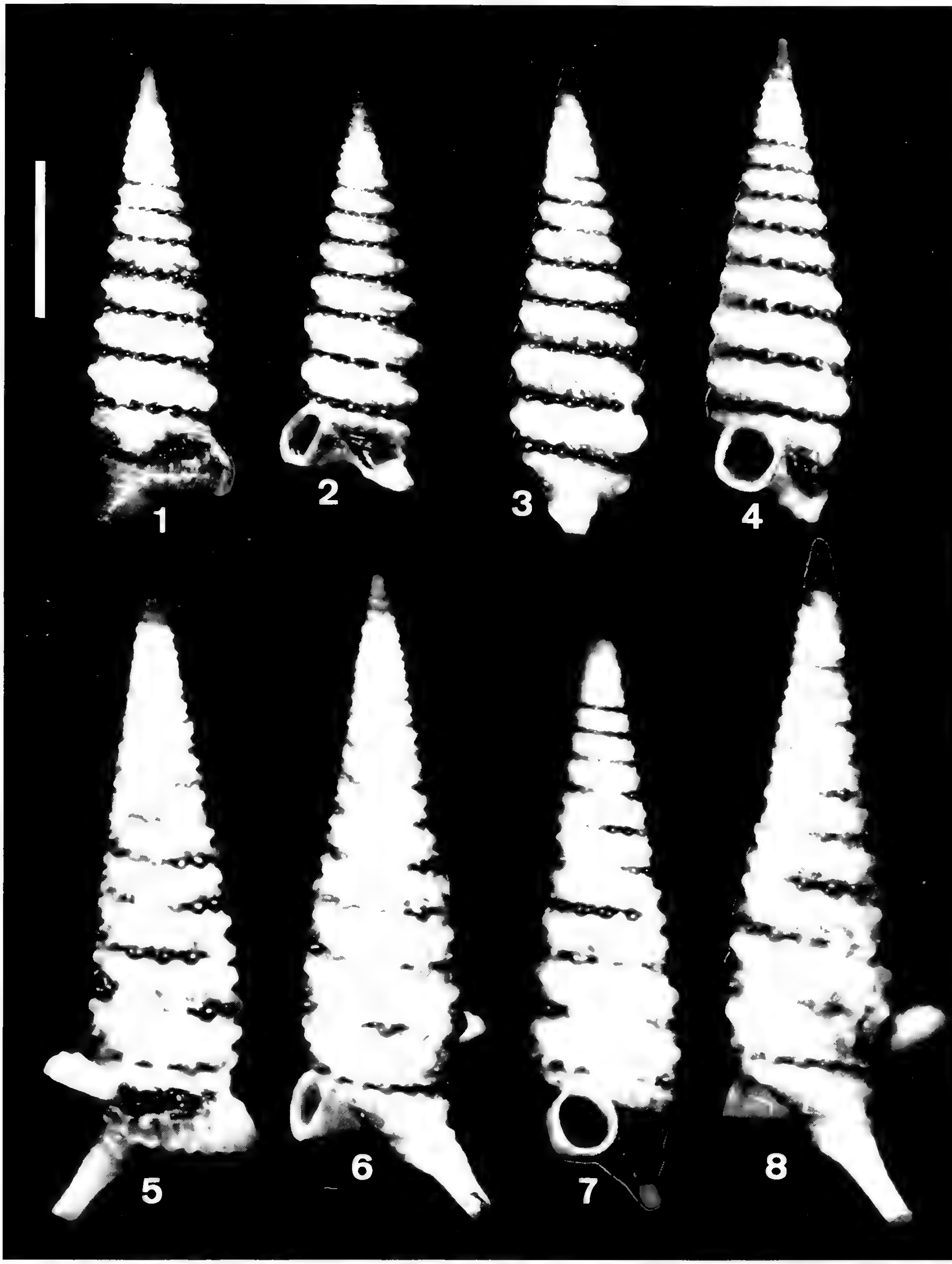
The type material is considered lost (DE JONG & COOMANS, 1988). It is necessary for nomenclatural stability to designate a neotype (Fig. 1), which is 5.5 mm, and is deposited in the MNCN with the number 15.05/6823. Its origin is from Cienfuegos.

Description

The shell (Figs. 1-4) was before figured in WARMKE & ABBOTT (1961: pl. 13, fig. j) and in ABBOTT (1974: fig. 1132). *Cerithium mirabile* C. B. Adams, 1850, which type is represented in CLENCH & TURNER (1950: pl. 38, fig. 1), is a shell without protoconch, but it seems to be the same species.

It is a very well known and repeatedly described species (for example, in ABBOTT, 1974: 111). Dimensions between 4.1 mm to 7.0 mm. To these descriptions it is necessary to add:

The protoconch (Fig. 20) is dark brown with four spiral whorls. It has an average of 0.48 mm of length. The embryonic whorl is 0.13 mm in width and is covered by many small semispheric tubercles which are irregularly



Figs. 1-4. *Iniforis turristhomae*. (Fig. 1: neotype, MNCN).
Figs. 5-8. *Iniforis pseudothomae* n. sp. (Fig. 6: holotype, MNCN; Figs. 5, 7, 8: paratypes, CER).
(scale: 1 mm)

distributed (Fig. 21). Two spiral cords crossed by axial ribs run along the remaining whorls.

The animal is translucid white, with very small milky-white blotches, some on the entire body, but most on the cephalic part. There is yellow pigmentation on the propodium and on the dorsal part of the metapodium. Some small red violet spots are present on the dorsum of the foot, more concentrated in its central part. Tentacles are translucid.

Radula with many teeth, all very similar among them, with three long cusps (Figs. 31-32 & 34). BANDEL (1984: fig. 95, pl. 5, fig. 4) previously illustrated this radula.

Operculum (Fig. 33) almost circular, translucid whitish-yellow, with a central nucleus, and 4-6 spiral whorls. Ovoid insertion surface form placed in a lateral position.

Comments

The description of *I. turristhomae* is based in a figure of Chemnitz lacking the necessary details for defining the species. However, the authors who before represented the shell, agreed about the shells belonged to this species. At present, the existence of other species with similar shell (see below) and with very similar but different protoconch, makes it necessary to designate a neotype in order to preserve the nomenclatural stability.

KOSUGE (1966: figs. 21 & 22 a, b & c) shows the radula of two species of *Iniforis*: *I. albogranosa* and *I. concors*. These radulae have a pentacuspid rachidian tooth, tricuspid lateral and monocuspid marginal teeth. The radula represented by MARSHALL (1983: fig. 4, H) for *Iniforis* cf. *violacea* is similar to the one of the present species. So it must be considered that the radula of this genus can have a variable number of cusps on its teeth.

Triphora turrissimilis Nowell-Usticke, 1971 is not a synonym of this species, but a triphorid not included in the genus *Iniforis* because its anal canal is close to the aperture. The same condition occurs in *Triphora bermudensis* Bartsch, 1911, which was sometimes synonymized with the present species (ABBOTT, 1974).

Iniforis casta (Hinds, 1843)
Figs. 9, 10, 11, 24

Triforis (*Mastonia*) *castus* Hinds, 1843. Ann. Mag. Nat. Hist., ser. 1, 11: 20.

Material examined

Type material: Lectotype, 4.9 x 1.7 mm from S. Vincent, W. Indies, BMNH number 196536-37, Gray collection, selected by Moolenbeek & Faber (in press). A paralectotype is a fragment without protoconch and with a continous dark spiral line, and is probably a different species.

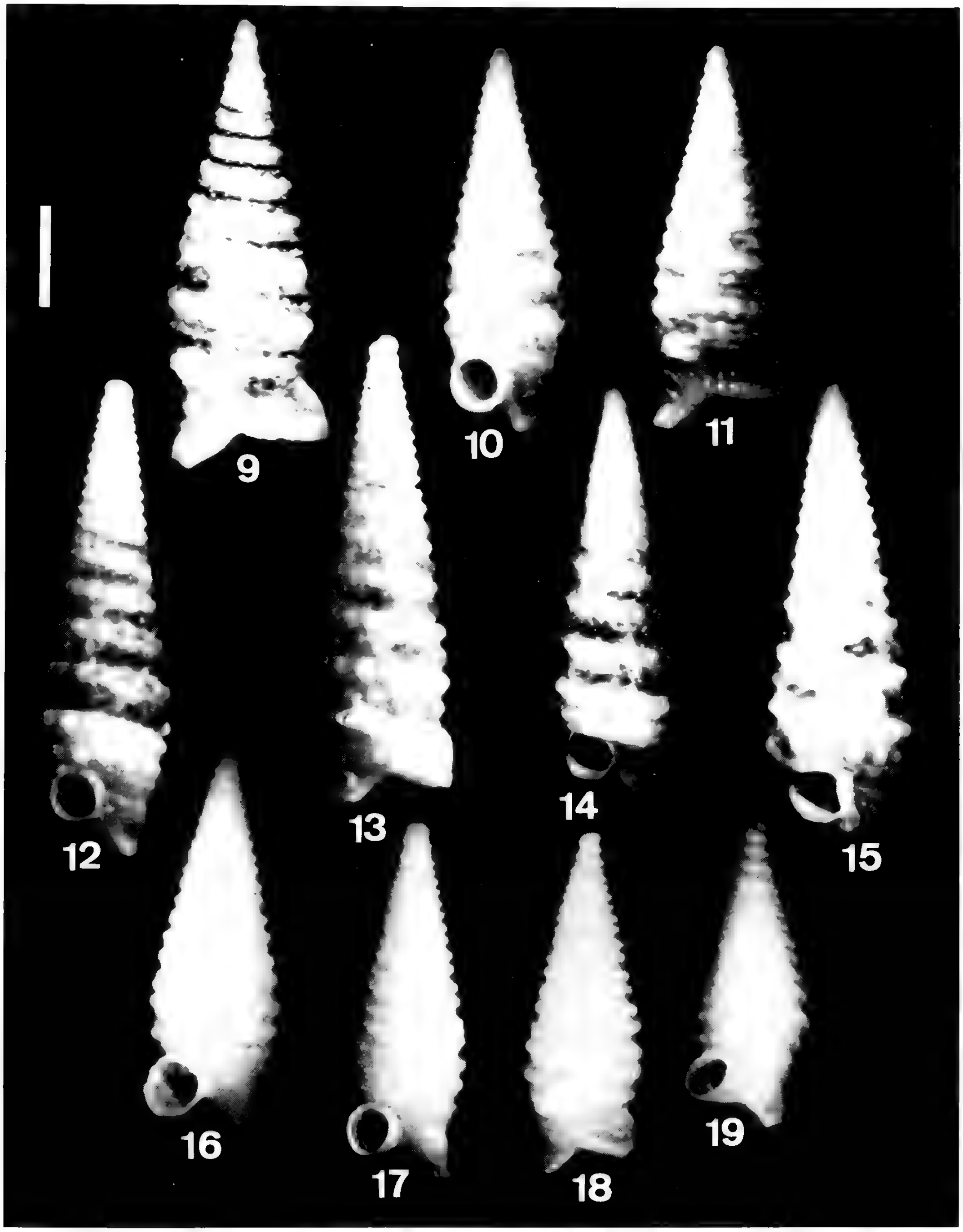
North of Cuba: 8 shells and 24 fragments with protoconch at 5 m in Jibacoa (CER); 1 shell at 6 m in Yacuanabo (CER).

South of Cuba: 1 shell at 10 m in Cayo Cantiles and 2 fragments with protoconch at 20 m in Cayo Matías, Archipelago of Los Canarreos (CER).

Description

Shell (Figs. 9, 10 & 11) slender and elongated, slightly curved in the last whorls, cream-white, crossed by an spiral brown band (always discontinous) on the lower row of tubercles. Dimensions: between 4.0 to 5.5 mm in length.

Protoconch (Fig. 24) with between 2 and 3.5 whorls with faint transition protoconch/teleoconch. Its width is 0.30 mm. Spiral striae are present at the beginning but immediatly a very tiny axial sculpture is present. Two spiral cords run along the protoconch



Figs. 9-11. *Iniforis casta*, Jibacoa (Cuba).
Figs. 12-15. *Iniforis carmelae* n. sp. (Fig. 12: holotype, MNCN; Fig. 13: paratype, AMNH; Figs. 14-15: paratypes, CER).
Figs. 16-19. *Iniforis immaculata* n. sp. (Figs. 16 & 18: paratypes, CER; Fig. 17: holotype, MNCN; Fig. 19: paratype, AMNH).
(scale: 1 mm)

ending with a single cord, extended in variable distance.

Teleoconch with about 8-10 whorls, each one with two rows of tubercles, separated by a fine undulated spiral rib. The first two whorls are white but in the remaining whorls the lower row is irregular brown. A dark blotch is present on the base of the siphonal tube. There are three tuberculated cords on the body whorl some of which extend onto the base. The aperture is circular. The anal aperture in the suture is slightly separated from the aperture. The siphonal tube is closed, narrow and slightly curved at its end.

The animal is unknown.

Comments
I. casta is easily differentiated from *I. turristhomae* by its white protoconch with less whorls, and also by its discontinous brown spiral line.

Iniforis pseudothomae n.sp.
Figs. 5, 6, 7, 8, 22, 23

Material examined
North of Cuba: 2 shells at 5 m, in Baracoa (CER).

South of Cuba: 10 shells at 6 m, in Cayo Cantiles and 6 shells at 20 m, in Cayo Matías, Arquipelago of Los Canarreos (CER); 23 shells between 10 to 20 m in the Cienfuegos Bay and 32 shells at 45 m in Rancho Luna, Cienfuegos (type material and CER).

Type material
Holotype (Fig. 6) of 7.4 mm, from Cienfuegos, MNCN 15.05/6820; 5 paratypes in the IES; one paratype in AMNH 226459, MNHN, BMNH 1992133, ZMA 3.93.005 and ten in the CFG and CER (all from the Cienfuegos lot).

Description
Shell (Figs. 5-8) slender and elongated, pointed, with a rectilinear profile except in the last whorl. Whitish colour with two rows of tubercles: the upper one is white and the lower has an irregular light brown spiral band. Dimensions: between 5.0 to 9.5 mm.

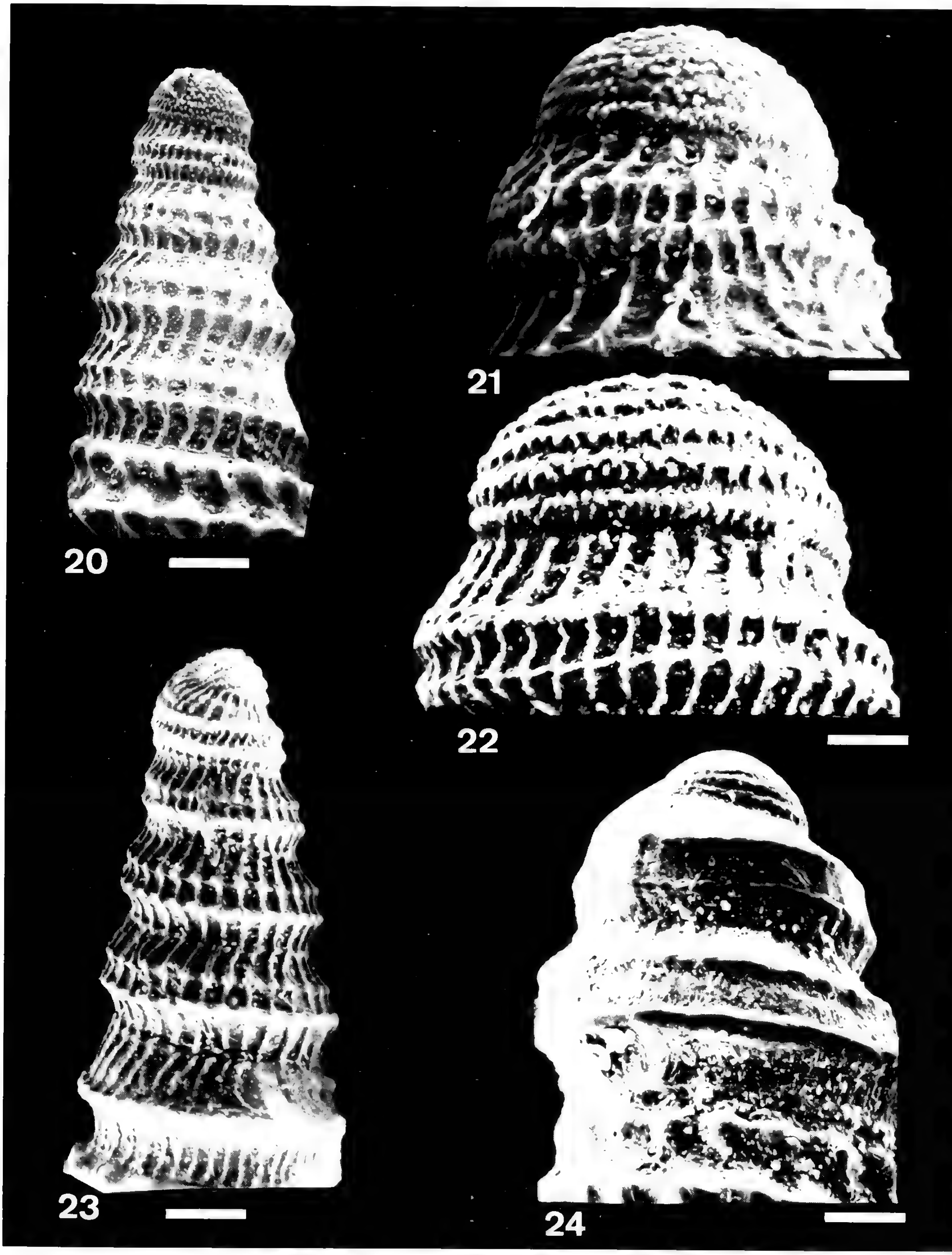
Protoconch (Fig. 23) brown in colour, average 0.67 mm in length. Width of the embryonic whorl is 0.17 mm and it has its surface covered with many small tubercles grouped in bands (Fig. 22). The larval shell has up to five whorls, four of them showing two spiral fine cords crossed by axial ribs; in the last whorl there is a single cord, also crossed by axial ribs.

The teleoconch has between 10 to 15 whorls with a very rectilinear profile. The suture is not evident. Two rows of tubercles are present, all connected by a spiral cord. The upper row is white and bordered by two fine cords, one near the suture and the other close to and below the tubercles. The inferior row is a irregular discontinous light brown. On the last whorl, there are several spiral cords near the base, most of them without tubercles; the last cord is placed on the siphonal tube. The aperture is circular, clearly separated from the shell. The siphonal tube is elongated, closed and a slightly curved, darker near the aperture. One new tube is placed on the suture a little before the end of the spire, representing the anal canal. The siphonal and the anal tubes are usually elongated.

Etymology
The specific name refers the similarity with the precedent species (*I. turristhomae*).

Type locality
Cienfuegos, in the south of Cuba.

Discussion
I. pseudothomae is very similar to *I. turristhomae* but it has a more rectilinear profile and is usually larger (one specimen had up to 20 whorls of teleoconch). The most distinctive character is the lower row of tubercles of irregular brown colour present in *I. pseudothomae*; the shell is lighter in colour



Figs. 20-21. *Iniforis turristhomae*. (Fig. 20: protoconch; Fig. 21: embryonic shell).
Figs. 22-23. *Iniforis pseudothomae* n. sp. (Fig. 23: protoconch; Fig. 22: embryonic shell).
Fig. 24. *Iniforis casta* (protoconch).
(scale: protoconch: 0.1 mm; embryonic shells: 0.05 mm)

than *I. turristhomae*. The embryonic shell is slightly larger than *I. turristhomae*, and its tubercles are grouped into obvious cords; also the abapical whorl of the protoconch, with one spiral cord, is larger. The siphonal and anal tubes in *I. pseudothomae* are longer than in *I. turristhomae*.

The other species of this genus, mentioned in the present work for the Caribbean area, have protoconchs that indicate lecithotrophic development.

ODE (1989: 109), speaking about *Triphora turristhomae*, commented that in some rare cases, the specimens observed have the brown band "..broken into a line of dashes". These specimens are likely to be *I. pseudothomae* n. sp. LEAL (1991: 123, pl. 16, figs. L-M) described and illustrated *Triphora* sp. 2, which could be the present species because "...it differs (from *T. turristhomae*) by having a rather diffuse coloration pattern of brown spots over entire whorls, instead of the single, brown abapical spiral row of nodules". Therefore, we expect *I. pseudothomae* to have a wider range throughout the Caribbean region.

Iniforis carmelae n.sp.
Figs. 12, 13, 14, 15, 28, 29, 30

Material examined
North of Cuba: 4 shells at 15 m, in La Herradura (CER); 3 shells and 4 fragments at 5 m, in Jibacoa (CER); 3 shells at 5 m, in Baracoa (CER).

South of Cuba: 9 shells at 15 m, in Cayo Matías, 1 shell at 5 m, in Cayo Diego Perez (Archipelago of Los Canarreos) (MNCN); 22 shells and 5 fragments at 45 m, in Rancho Luna (Cienfuegos) (type material).

Type material
Holotype (Fig. 12) of 5.2 mm, from Cienfuegos, MNCN 15.05/6822. One paratype in ZMA 3.93.006, AMNH 226457, IES, BMNH 1992134, MNHN, five in the CFF and fifteen in the CER (all from the Cienfuegos lot).

Description
Shell (Figs. 12-15 & 28) elongated and slender, translucent cream-white, with two rows of tubercles, lower one marked by an irregular brown band. Dimensions between 4.2 mm to 5.9 mm.

Protoconch (Figs. 29-30) blunt, sometimes variable in width (average 0.34 mm), with about 2 1/2 whorls. It begins with a circular smooth nucleus which shows several growth lines. The first whorl is rounded, with a spiral cord that begins at its end. The first whorl shows, in fresh shells, very fine irregular spiral lines devoid of axial sculpture. On the second whorl there are incomplete axial ribs which change into tubercles in some specimens.

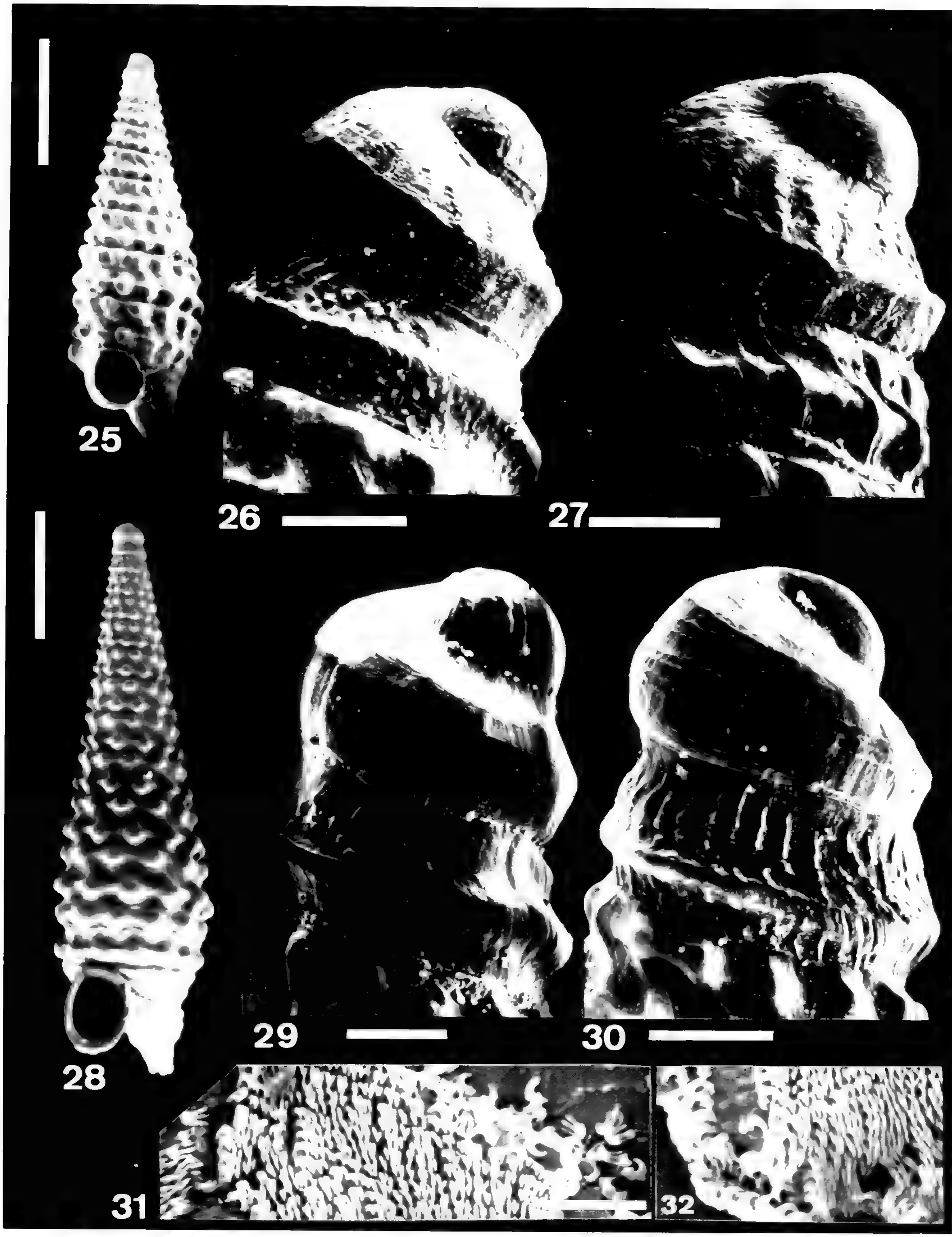
The teleoconch shows about 10 whorls, each one with two rows of tubercles. Suture not well marked. A fine spiral rib appears about the 9-10 whorl below the upper row of tubercles and bordering them closely. On the last whorl there are other three non-tuberculated cords below the last two rows. The anal tube is opened in the suture slightly before the end of the spire. The aperture is circular and separated from the shell at its end. The siphonal canal is slightly elongated, closed, and slightly curved. The fragments of the shells show that the interior core is brown.

The animal is unknown.

Etymology
The name is employed in memoriam of a daughter of the senior author.

Type locality
Cienfuegos in the South of Cuba.

Discussion
The paucispiral protoconch differs from those species with planktotrophic development (*I. turristhomae* and *I. pseudothomae*). Other



Figs. 25-27. *Iniforis inmaculata* n. sp. (Fig. 25: paratype, CER; Figs. 26-27: protoconchs).
Figs. 28-30. *Iniforis carmelae* n. sp. (Fig. 28: paratype, CER; Figs. 29-30: protoconchs).
Figs. 31-32. *Iniforis turristhomae* (radula).
(scale: shells: 1 mm; protoconch: 0.1 mm; radula: 0.01 mm)

species with similar coloration pattern such as *Triphora bermudensis* Bartsch, 1911, *T. elvirae* De Jong & Coomans, 1988 and *T. ellyae* De Jong & Coomans, 1988, have multispiral protoconchs.

I. casta has a more inflated shell, its protoconch is smaller, and presents differently sculpture. The differences with the species to be shown below will be made after its description.

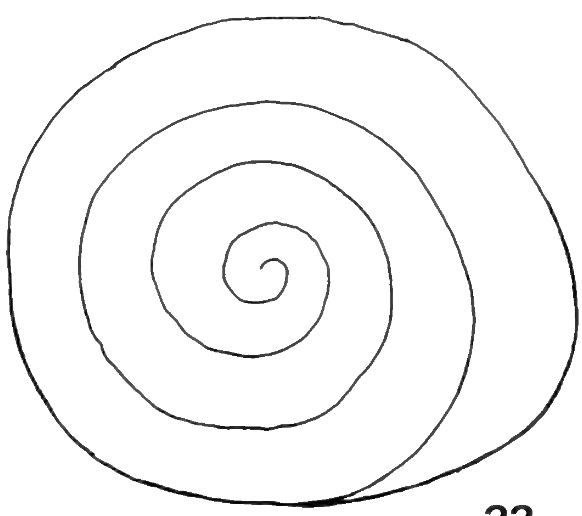
Iniforis immaculata n.sp.
Figs. 16, 17, 18, 19, 25, 26, 27

Material examined
North of Cuba: 3 shells and 2 fragment at 5 m, in Jibacoa; 2 shells and 1 fragment at 4 m, in Baracoa.

South of Cuba: 5 shells and 7 fragments at 15 m, in Cayo Matías; 4 shell and 3 fragments at 15 m, in Rancho Luna and 3 shells and 4 fragments between 10 to 45 m, in Cienfuegos Bay. Most of the shells are type material; rest in CER.

Type material
Holotype (Fig. 17) of 4.00 mm, from Cienfuegos, MNCN 15.05/6821. One paratype in the collections of IES (from Cienfuegos), AMNH 226458 (from Rancho Luna, Cienfuegos), BMNH 1992135 (from Cayo Matías), MNHN (from Cayo Matías) and ZMA 3.93.007 (from Jibacoa); four in the CFG (from Rancho Luna) and seven in the CER (from Rancho Luna and Cienfuegos Bay).

Description
Shell (Figs. 16-19 & 25) slender and elongated, glossy, slightly curved in last whorls, with a slightly translucent white colour. Dimensions: between 3.5 mm to 4.9 mm.



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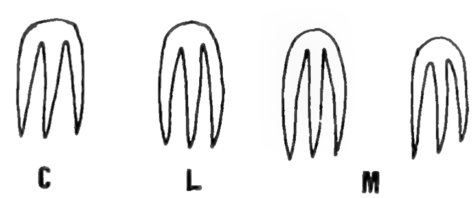

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Fig. 33.- Operculum of *Iniforis turristhomae* (scale: 0.5 mm).
Fig. 34.- Radular teeth of *Iniforis turristhomae*: C- central tooth; L- lateral tooth; M- one of the marginal teeth.(scale 0.005 mm)

Protoconch (Figs. 26-27) blunt, sometimes variable in width (average 0.33 mm), with between 2 and 2 1/2 whorls. It begins with a circular nucleus (Figs. 26-27) which is crossed by several lines. The first whorl is rounded and it has a peripherical spiral cord. Above this cord small sigmoidal axial ribs appear. These ribs are present in the second whorl, where they are narrower and more frequent, and where they become tubercles.

The teleoconch has about 8 whorls, each one with two rows of tubercles and slightly marked suture. A fine spiral rib begins below the upper row of tubercles between the fifth and the sixth whorls. In the last whorl, two other non-tuberculated cords appear near the base, abapically to the other ones. The anal tube is open in the suture, just before the aperture. Aperture is circular and very regular. The siphonal canal is short, closed, slightly curved towards the dorsum. The interior of the shell is totally white.

The animal is unknown.

Etymology
The specific name refers at the totally white colour of the shell.

Type locality
Cienfuegos, in south Cuba.

Discussion
The paucispiral protoconch distinguishes this species from those also white with planctotrophic development, like *Cosmotriphora melanura* (C. B. Adams, 1850). Other Caribbean species with paucispiral protoconch (*T. peetersae* Moolenbeek & Faber, 1989 and *T. calva* Faber & Moolenbeek, 1991) have a different dark colour.

A similar species having a paucispiral protoconch is *I. carmelae* n. sp., but this species has brown colour in the lower row of tubercles in last whorls. The profiles of both species are also different, *I. carmelae* being more rectilinear. Their protoconchs have consistent small differences only detectable using SEM: tiny spiral lines in *I. carmelae* and axial sculpture in *I. immaculata*. The fragments of both species show that the color of their interior is also different: white in *I. inmaculata* and brown in *I. carmelae*.

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Description of a new species of the genus *Haustellum* Schumacher,1817 (Gastropoda: Muricidae) from the Western Indian Ocean.

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KEYWORDS: Gastropoda, Muricidae, *Haustellum* , *franchii* n.sp., Somalia.

ABSTRACT: An undescribed species belonging to the genus *Haustellum* has been found in deep water off the most northeastern point of Africa; a comparison is made with the closest species included in the "group" of *Haustellum* s.s.

INTRODUCTION.

The genus *Haustellum* shows a close relationship with *Murex* s.s. Linné,. 1758, and in the PONDER & VOKES (1988) revision of the Indo-West Pacific species of the two genera, the authors ascribed to *Haustellum* certain species previously included by other taxonomists (e.g. RADWIN & D' ATTILIO, 1976; FAIR, 1976) in the genus *Murex* s.s.

The main difference between the two taxa has been found in the reproductive system : the species of *Haustellum* show a non-muscular ejaculatory duct, whereas the species of *Murex* have a muscular one (PONDER & VOKES,1988:10, 17).

As well the shell body presents some differences, the lack of labral tooth and the spineless (or almost spineless) varices are typical for the genus *Haustellum* (PONDER & VOKES, 1988 : 7, 14, 17). Nevertheless, *Haustellum* sensu Ponder & Vokes can be easily divided, according to several shell characters, in two distinctive groups: a first one including low spired species with globose and spineless body whorl, very developed inductura, long and smooth, or nearly so, siphonal canal, and a second group including the species moved by PONDER & VOKES (1988) from *Murex* s.s. to *Haustellum*. HOUART (1990 : 331), making this division, denominates the first group *Haustellum* s.s. and the second *Haustellum* s.l.; it would be appropriate, if confirmed by further studies, to give them an official taxonomic status.

Haustellum franchii n. sp.

Description

Shell moderate in size for the genus, club-shaped, low-spired, protoconch paucispiral of one and one half to two smooth, bulbous whorls, terminating in a straight, marked varix and followed by six convex, rounded postnuclear whorls. Suture impressed and weakly undulate, three rather strong, rounded varices per whorl, noticeable from third teleoconch whorl onwards, excavated behind, spineless on body whorl, with a small spine-like tubercle on shoulder of spire whorls. Four or five axial costae in each intervarical space, weak axial ribs discontinuously distributed between them; four spiral cords per whorl on first two teleoconch whorls, afterwards minor cordlets appearing, alternating with principal ones, for a total of 26/30 on body whorl; spiral continuing on higher half of siphonal canal. Primary cords, crossing axial costae, generate prominent and rounded tubercles, stronger on shoulder edge. Aperture obliquely ovate, anal notch broadly open and shallow, labrum protruding, sharply edged and weakly crenulate, with a small hollow prickle at posterior end just following apertural varix. Inner side of outer lip with 13-15 lirations,

columellar lip adherent posteriorly and detatched anteriorly, forming an highly developed inductura, outside sculptured with swollen ribs, smooth inside. Siphonal canal straight, moderately long, just less than half of total shell length, narrowly open and communicating with stomatic aperture trough a sinuous slit, one small spine present near base of body whorl, surface nodose.

Ground colour cream with dark brown and reddish-brown spiral lines, from fourth teleoconch whorl onwards, and topping primary cords; first line on shoulder edge, a second one, noticeable on penultimate whorl, just over suture; on body whorl : one on shoulder edge, two adjacent just under midbody line and one on basal zone; pattern continuing on spiral sculpture of siphonal canal. Aperture withish, inner lip edge inside reddish coloured; brownish bands on siphonal canal regularly distributed.

Comparison

H. franchii falls under the *Haustellum* s.s. group; few species and subspecies belonging to this group are present in the western side of the Indian ocean, namely : *H. haustellum haustellum* (Linné,, 1758) with a wide Indo-Pacific distribution, *H. haustellum longicaudum* (Baker, 1891) probably limited to the Horn of Africa area, including southern part of the Red Sea, *H. fallax* (Smith, 1901) from Natal to Mozambique.

The new species differs from the first two above mentioned because of its lower spire, more rounded whorls profile, lighter colouration lacking blotches; *H. fallax* has a similar low spired shells, but with a more angled shoulder, heavier and broader varices and axial ribs, darker ground colour and different pattern, moreover the spine on the siphonal canal, sometime present also in *H. haustellum*, is much more developed and in more anterior position than *H. franchii* one. Two other taxa included in the *Haustellum* s.s. group : *H. kurodai* (Shikama, 1964) and *H. vicdani* Kosuge, 1980, from Japan and the Philippines, have been synonymized by PONDER & VOKES (1988) with *H. haustellum.*

A rare species from south west Australia, *H. wilsoni* D'Attilio & Old, 1971 has a certain likeness in shape with the new species, but differs in its pustulose sculpture, more rounded shoulder, deep channelled suture and ground colours.

HOUART (1990 : 333, figs. 14-16, 32) mentions a probably undescribed species of *Haustellum* found in Tanzania and Madagascar waters, but it has very different features (in shape, colour and sculpture) from *H. franchii*. *H. hirasei* (Hirase, 1915) has an almost identical colouration and pattern, but this taxon belongs to *Haustellum* s.l. group.

Type Locality

Trawled by shrimp boats at 200-250m depth off Ras Hafun, northeastern Somalia.

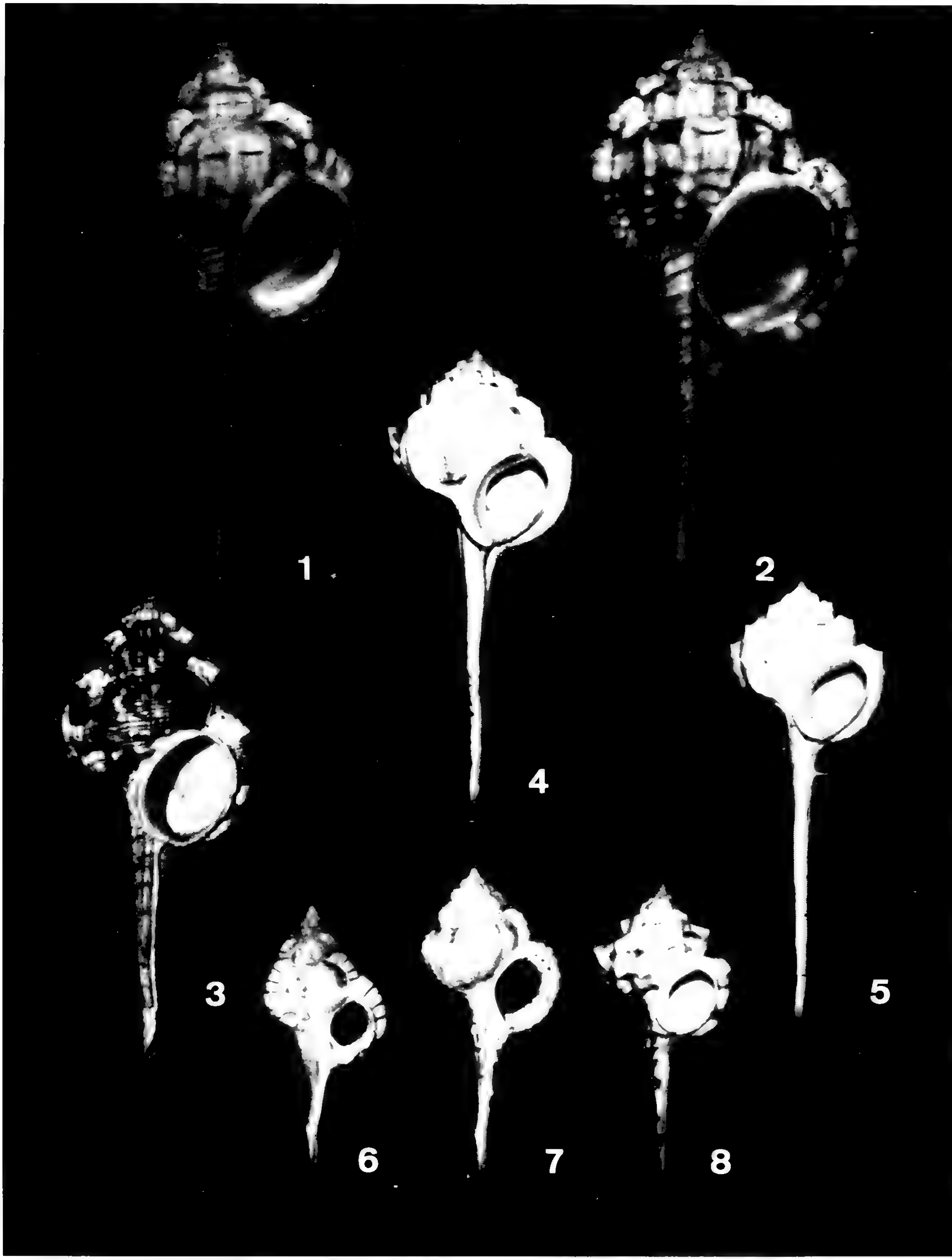
Type Material

Three specimens studied : holotype, 59.80mm, IRSBN, Bruxelles, no. 27962/459; paratype 1, 66.85mm, F.Franchi Col., Piacenza; paratype 2, 30.30mm,R. Houart Col., Ezemaal.

Etymology

I dedicate this species to Dr. Fabrizio Franchi from Piacenza, a keen conchologist and a great friend.

Figures 1-8 (opposite)
1. *H. franchii*, holotype, 59.8mm. 2. *H. franchii*, paratype 1, 66.85mm. 3. *H. haustellum haustellum*, 120mm, Mactan Isl., Philippines; 4. *H. vicdani*, 130mm, Bohol Isl., Philippines; 5. *H. kurodai*, 120mm, Siasi Isl., Sulu Sea, Philippines; 6. *H. hirasei*, 63mm, Tosa Bay, Japan; 7. *H. wilsoni*, 72.5mm, Freemantle, W. Australia; 8. *H. fallax*, 79.5mm, off Durban, S. Africa.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RADWIN, G. E., & A. D' ATTILIO 1976. Murex shells of the world. An illustrated guide to the Muricidae. Stanford, 1-284.

Description of a new species of the genus *Metula* H. & A. Adams, 1853 (Gastropoda,Prosobranchia,Buccinidae) from the Western Indian Ocean.

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KEYWORDS: Gastropoda, Buccinidae, Pisaniinae, *Metula*, *somalica*, new species, Somalia.

ABSTRACT. Since its origin the systematic arrangement of the genus *Metula* has been rather controversial; this problem has been settled only recently, by means of anatomical studies, but there are still some disagreements among taxonomists. An unknown buccinid belonging to this genus is here described and is given the name *Metula somalica*.

INTRODUCTION.

The taxonomy of the name *Metula* and other correlated genera has been clarified only lately, after an old controversy between Ponder and Cernohorsky. PONDER (1968, 1973) included these genera in the Colubrariidae, separating them from Buccinidae by anatomical differences. CERNOHORSKY (1971) recognized some affinities between the radular apparatus of *Ratifusus* and *Iredalula* and that of Buccinidae, and Suggested their inclusion in the Pisaniinae subfamily. This theory has been followed by most taxonomists, BEU & MAXWELL (1987) also put the taxon *Metula* in the Pisaniinae. BOUCHET (1988) represents for the first time the radular structure of a *Metula* species, comparing it with that of *Pisania striata* (Gmelin, 1791); owing to the remarkable differences between them, he states that more work shall be necessary to establish the true relationship between the two genera, moreover he comes to the conclusion that the Atlantic buccinid genus *Bartschia* Rehder, 1943, on account of its similar characters, should be changed into a subgenus of *Metula*. REHDER (1943) described the genus *Antemetula*, with *Buccinum metula* Hinds, 1844 as type species, distinguishing it from *Metula*; CERNOHORSKY (1971) synonymized *Antemetula* with *Acamptochetus* Cossman, 1901,and a few years later KILBURN (1975) relegated both *Acamptochetus* and *Antemetula*, with its subgenus *Colubrarina* Kuroda & Habe, 1971, to the synonymy of *Metula*. In addition to these debates of anatomical and morphological nature, there has long been nomenclature confusion concerning the type-species *Buccinum clathratum* Adams & Reeve, 1850; this was originally described from South Africa, KNUDSEN (1956) figured it as a West-African species (Spanish Guinea), KILBURN (1975) redenominated it as *M. knudseni*, being the former taxon junior synonym of *B. clathratum* Kiener, 1834; lately EMERSON (1986) settled this question by giving the name *M. clathrata* to a West-American species, and *M. clathrata* sensu Knudsen (= *M.knudseni* Kilburn) has been confirmed as an undescribed species and named by Bouchet (1988) *M. africana*.

Metula is typically a deep water genus,and a few new species have been trawled in the last few years along the East African coast of the Indian Ocean: *M. boswellae* Kilburn, 1975, *M. crosnieri* Bouchet, 1988, *M. bozzettii* Parth, 1989, *M. angioyorum* Parth, 1992, and *M.*

chetyzecchiae Bozzetti, 1992; KILBURN (1975) represented an unknown species trawled off Durban, which actually can be identified as a large, worn specimen of *M. chetyzecchiae*.

Metula somalica n. sp.

Description

Shell solid, fusiform , spire high and sharp, upper part orthoconic, lower cyrtoconic, protoconch missing, teleoconch consisting of six convex whorls. Suture incised, aperture high, about half total length, narrow, almond-shaped, siphonal canal short, slightly bent to the left, anal sulcus deep. External lip thickened by a varix, with a sharp edge, internal side smooth or weakly wrinkled. Parietal callus normally developed; sculpture finely beaded, consisting of dense spiral threads and weaker axial ribs. Spiral sculpture stronger on anterior end. About sixty spiral threads on the body whorl and siphonal canal, twenty-four on the penultimate whorl, twenty on the preceeding one; scupture of early whorls hardly visible due to erosion. Ground colour beige-cream, whitish at the top of the spire, with bands of large, axially oblong, reddish-brown blotches. Distribution of bands as follows : none on the early three whorls, one subsuturally positioned and one half-covered by the subsequent whorl in the fourth whorl, two in the penultimate whorl and three in the body whorl. Corresponding blotches of two close bands are often joined by finer flammules of the same colour. Lowest band on the body whorl half wide compared to the upper ones. In the siphonal area a darker band, continuous on dorsum side, interrupted on aperture side. Peristome whitish or yellowish, inside of the mouth cream-coloured.

Discussion

Metula somalica, superficially resembles a dwarf *M. boswellae*, being three times shorter, but comparison should be made with similar sized species of Indo - Pacific distribution; the new species, compared with its closest ally, *M. daphnelloides* Melvill & Standen, 1903, has a lower spire, a stronger outer lip, a deeper anal sulcus, more inflated whorls, siphonal canal narrower and shorter, a weaker parietal callus and a larger size. *M. hindsii*, H. & A. Adams, 1858, has a slender spire, a narrower mouth and less inflated whorls. *M. metula* (Hinds, 1844) has a slender spire and a stronger axial sculpture. Moreover, an important and distinctive character is the lack of teeth on the outer lip in *M. somalica*.

Type locality

All specimens have been trawled off Ras Hafun, Northeastern Somalia, on sandy bottoms at 200-250 metres depth.

Type material

Holotype, 28.2mm,IRSBN, Bruxelles,no. 27954/458; paratype 1, 24.9mm, Natal Museum, Pietermaritzburg, no. L236/T870; paratype 2, 25.8mm, author's coll., Milan;paratype 3, 24.4mm, author's coll.; paratype 4, 26.8mm, Brink coll., Durban; paratype 5, 26.mm, Inst. of Mal., Tokyo, no. IMT-92-49; paratype 6, 23.3mm, author's coll.

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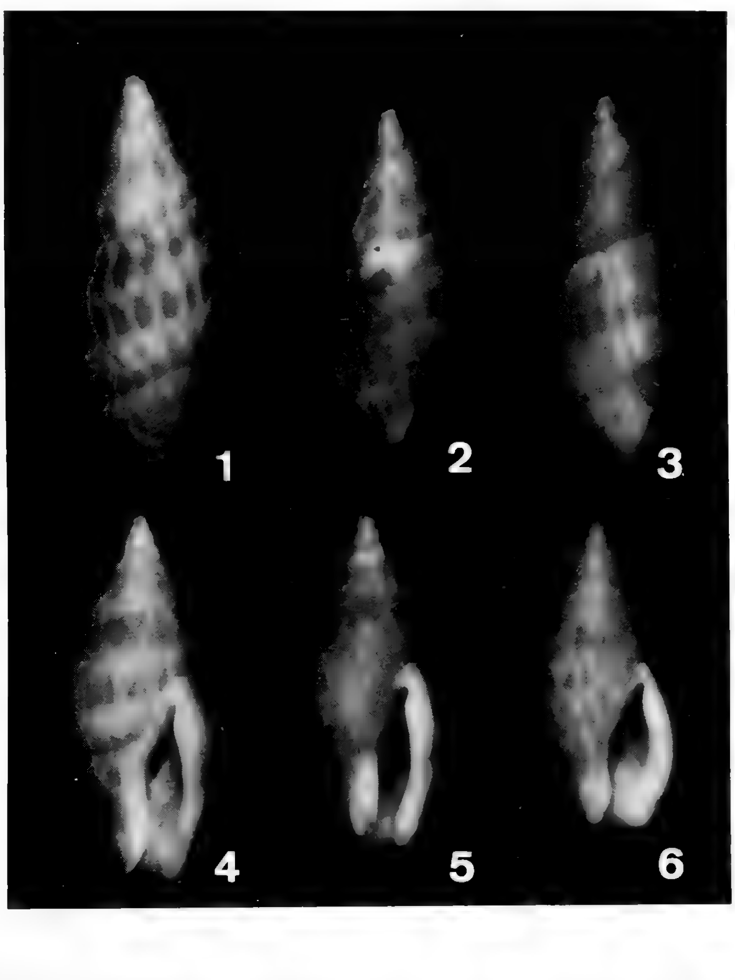

Metula somalica. Fig. 1 holotype, fig. 2 paratype 1, fig. 3 paratype 2, fig. 4 paratype 4, fig. 5 paratype 3, fig. 6 paratype 6,

Conus cacao Ferrario, 1983, taxonomical and systematic context (Mollusca : Prosobranchia : Conidae).

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KEY-WORDS : Mollusca, Gastropoda, Conidae, *Conus cacao*, North-West Africa

ABSTRACT : As part of a revision concerning the taxonomy and the systematics of the Conidae from North-Western Africa, the research reveals that the types of *Conus franciscanus* Hwass in Bruguière, 1792 and *Conus lamarckii* Kiener, 1845 are within the natural range of variability of *C. guinaicus* Hwass in Bruguière, 1792, and thus are conspecific with this species.
Another separate species, usually admitted by authors as being *C. lamarckii* ("auctorum", non Kiener, 1845), and more often considered as a "variety" of *C. mercator* Linnaeus, 1758, remained without a valid name.

RESUME : Dans le cadre d'une révision concernant la taxonomie et la systématique des Conidae du Nord-Ouest Africain, les recherches ont démontré que les types de *Conus franciscanus* Hwass in Bruguière, 1792 et de *Conus lamarckii* Kiener, 1845, font partie de la variabilité naturelle de *Conus guinaicus* Hwass in Bruguière, 1792, et par conséquent sont conspécifiques avec cette espèce.
Une autre espèce distincte, généralement identifiée par les auteurs comme *Conus lamarckii* ("auctorum", non Kiener, 1845), et le plus souvent considérée comme une "variété" de *Conus mercator* Linné, 1758, était restée sans nom valide.

Conus cacao Ferrario, 1983 : p.146 + fig.

Original Description

"Often confused with *C. lamarckii* Kiener, a species which is related with *C. mercator*, this *Conus* on the contrary seems more allied with the mediterranean *C. ventricosus*, as indicates the two white bands inside the purple-brown aperture. Heigh of more than 3 cm (2,4 and 3,5 in the figured specimens) it has a colouration that varies between pale olive-green and chocolate-brown, with very fine axial lines, and 2-3 close reticulated bands. The shoulder is rounded ; the spire, strongly eroded, brown with white dashes, presents 5 fine grooves immediately below the suture between the whorls. The periostracum is velvet. Not very common, it lives in sand between the rocks of the littoral in some tens of meters depth, and is endemic from Senegal."

The same description and picture were reproduced in 1988, in a further publication : "Il Grande Libro delle Conchiglie" by the same editor, p. 113. The figured shells must be considered as syntypes.

Type

The largest specimen figured by Ferrario is here selected as lectotype of *Conus cacao*.

Due to the courtesy of Mr Ferrario, it is today deposited at the Museum National d'Histoire Naturelle in Paris. Its measurements are : 36.6 x 20.9 mm. (Fig. 1).

The second figured specimen (paralectotype, 24 mm) is preserved in the collection of Mr Ferrario.

Type Locality

Senegal. According with the original label of the lectotype, this one was collected between rocks at tide line in the bay of the estuary of La Somone river, Senegal.

Distribution

The species is endemic from Senegal and Gambia, between Yenne (South of Dakar) and Banjul (Gambia). Some specimens were collected more southern, near Cap Skirring and Kafoutine.

Material Examined

62 specimens were examined, 33 of which were measured, including the lectotype.

Additional Description

To the original description should be added some more characters : the spire is seemingly always eroded, so that the protoconch cannot be scrutinized. No larval shells were available. Consequently, counting the number of spire whorls was not easy. In a majority of shells (even when live or juvenile taken) only the 2 or 3 last spire whorls are intact. Thus, a precise valuation of the rate of the whorl expansion (WE) can be obtained only by mathematical ways (see morphometric measures and ratios).

Variability

The variability of the species concerns essentially the colour pattern, the colouration of the inside of the aperture, and the height of the spire (see tables). The background of the shell is olive-green, and totally covered with a network of very fine and close more or less straight undulating brown axial lines. Between this network, there are generally three bands, articulated with small lanceolate white dots. These bands are localized directly around the shoulder, on the first third of the body whorl, and a little lower than the median. Their width is variable, sometimes the bands are joined, sometimes the totality of the body whorl is covered with a net of lanceolate dots. In specimens with reduced patterns, subsists only a slight median band. (Fig. 3 c).

The colour of the aperture is the result of the violet colouration of the intermediate strate of the ostracum (mesostracum), this colour being visible by translucence of the inner strate (hypostracum). The mesostracum is pure white in *C. mercator*. The violet colour in *C. cacao*, well seen towards the edge of the lip, becomes paler towards the inside, because of the progressive thickening of the whitish hypostracum. This violet colour varies between dark violet and reddish-brown. Other characters are described in the morphological comparison table.

Taxonomic And Systematic Context

Before an examination of the validity of *C. cacao* Ferrario, it appears necessary to compare it with its congeneric species. There are two principal species and two colour forms (or ecotypes) which live in the same restricted area : *C. guinaicus* Hwass in Bruguière, 1792, *C. mercator* Linnaeus, 1758, *C. franciscanus* Hwass in Bruguière, 1792, and *C. lamarckii* Kiener, 1845.

Conus guinaicus Hwass in Bruguière, 1792 : p.697-698.

Hwass (in Bruguière) gave three latin diagnosis of three "varieties" which he distinguished in *C. guinaicus*. Their proposed translations are :

- Var. A : "Cone, shell conical rust-coloured, obsolete fasciae varying between whitish and brownish ; obtuse and maculated spire".
- Var. B : "Shell rust-coloured, distinct and broader fasciae."
- Var. C : "Shell with obsolete fasciae, ornamented with little pale bluish blotches."

Only two of these three "varieties" were illustrated in the "Tableau Encyclopédique", pl. 337, fig. 4 as Var. A, and fig. 6 as Var. C (KOHN, 1968 : 460). (Fig. 2 and 6).

The analysis of Bruguière's subdescription allows to identify as Var. A the most common phenotype from Senegal, which presents two more or less distinct bands, punctate with paler to whatever, sometimes cardiform and slightly bluish dashes on a reddish-brown to chestnut background. The periphery of the shoulder is often punctate with identical, but smaller dashes. Its figure in "Tableau", Pl. 337, Fig. 4 (our Fig. 4) is interesting to compare with some specimens of *C. cacao* (Fig.3 b) and could explain some ancient confusions. However, the intermediate flame-shaped dashes on the body whorl clearly indicate that the specimen figured in "Tableau" belongs to the species *C. guinaicus*, such flames being never seen in *C. cacao*.

The Var. B is distinct, according to BRUGUIERE (1792 : 698), only by lengthening of these dashes ("more considerable breadth of the fascies") and the formation of axial undulating flamules between this pattern.

The Var. C shows large distorded bluish-white dashes on a tawny to deep-brown background, with the presence, slightly below the midbody, of a paler band, distinctly visible by translucence of the lip. This whitish band also is seen in other "varieties", but is somewhat obliterated by the complexity of the external colour pattern. Only the shell of the Var. C today is available in the Hwass Collection at M.H.N.G. in Geneva (n° 1106/87 - 55,5 x 25,5 mm) and was designated by KOHN (1968) as lectotype of *C. guinaicus* Hwass in B. (Fig. 5).

Distribution

BRUGUIERE adds that these "varieties" occur on the "African coasts, and principally on the coasts of Guinea, which explains their name". LAMARCK (1822 : 493) confirms the same origin. The name of "Guinea" was used during the 18th century until to the second half of the 19th to designate the African coasts stretching from the Cap Vert peninsula (Senegal) to the actual Angola. The species today is known from Southern Mauretania to Sierra Leone and from the Canary Islands, where it seems rather rare. The affinities of *C. guinaicus* with *C. aemulus* Reeve, 1844 remain to be cleared up.

Variability

All the authors who treated about *C. guinaicus* noticed the extreme variability of the species (Fig. 7). This variability, even within one and a same population, is considerable and does not restrict to the three "varieties" described by Hwass and Bruguière. One can add several others, with as much intermediate variants, all these seeming only to be the result of the genetic variability of the species, unless today it is possible to impute them some determinant ecological causes. In this way, the forms shown on Fig. 7 come from the same ecological area which extends between Popenguine and M'Bour (Petite Côte, Sénégal).

Note

Although it was correctly identified by MARSH (1964) and by KAICHER (1977), *C. guinaicus* was confused with *C. ermineus* by WALLS (1979 : p. 285 above right).

Conus franscicanus Hwass in Gruguière, 1792 : p. 698-699.

Type

The specimen of the Hwass collection was selected by KOHN (1968) as lectotype of *C. franciscanus* Hwass in Bruguière. This specimen is kept at the M.H.N.G., Geneva, with the n° 1106/74/1 - 55 x 30,5 mm (Fig. 10).

Type Locality

"Africa" without other precisions.

Discussion

The lectotype of *C. franciscanus* is a faded, certainly beach taken and formerly polished shell, so that its original colour pattern, which appears as axially close lineated and reduced, became blurred and hardly recognizable. All its other characters oblige to recognize it as one of the multiple colour "varieties" of *C. guinaicus* : number of the spire whorls, characteristic median depression of the top of the two last spire whorls, texture of the body whorl, etc... RÖCKEL (1989 : 21-22) reached to the same conclusion. A single difference of colour patterns, in the context of the high natural variability of *C. guinaicus*, cannot be retained on a specific level, and *C. franciscanus* is concluded to be a colour variant.

Remarks

Kohn based *C. ventricosus* Gmelin, 1791 on one of the two figures published by KÄMMERER (1786, Pl. 6 fig. 3) and selected this figure as lectotype of *C. ventricosus* (KOHN, 1966 : Pl. 3, fig. 28).

The second figure of KÄMMERER (1786, Pl. 6, fig. 4) was also cited by Gmelin for his *C. ventricosus*, as well as by Hwass for his *C. franciscanus*. For this reason, I presume, Kohn synonymized the two names.

The controversy about the identity of *C. ventricosus* is for a long time. Some authors (BANDEL & WILS, 1977) pointed out the absence of a type-locality, of an available type-shell and an inadequate original description. The poor figure in Kämmerer may be interpreted as representing 4 or 5 diverse taxa : *C. caracteristicus* Fischer, *C. zeylanicus* Hwass, *C. guinaicus* Hwass, etc... These authors prefer using the name *C. mediterraneus* Hwass in Bruguière, 1792, proposed as a synonym by DAUTZENBERG (1920) and by KOHN (1968), but which presents the advantage to have a good and recognizable type figure, a well known type-locality and an original description that does not leave any doubt about the species concerned.

The generally admitted idea is that in the Mediterranean lives one and a sole species, if we except the rare ones which immigrate from the Red Sea via the Suez Channel (such as *C. fumigatus*) and eventually *C. desidiosus* Adams, whose identity remains to be cleared up. It seems more and more necessary to take an inventory of all the different Mediterranean populations to establish serious morphological, morphometric, ethological and anatomical comparisons and to set up proteinic electrophoresis, as well as genetic and phylogenic researches. It could not be excluded that we would find two different species : a first one which reaches rarely up to 30 mm in height (*C. mediterraneus*), and a second one which may reach 65 to 70 mm (*C. ventricosus*). For the moment, I personally prefer using the name *C. mediterraneus* for Mediterranean populations, and *C. ventricosus* for Lusitanian and North-West African populations.

Note

Some collectors, as well as some authors, consider several colour variants of separate species as being the "true" *C. franciscanus*. Between these, one can find some phenotypes of *C. mediterraneus*, *C. adansonii* Lamarck (= *C. hybridus* Kiener) or even of *C. aemulus* Reeve.

All these species belong to the same subgenus : *Lautoconus* Monterosato, 1923. As we indicated above, *C. franciscanus* is considered as a peculiar colour variant of *C. guinaicus* with a reduced pattern. This phenotypical particularity, which concerns only the colour pattern, also arises in other allied species. The colours vary from tawny to dark or blackish brown, but each specimen of these "colour forms" retains its other specific characters and may be identified by these characters, and not by more or less variable colour peculiarities.

Conus lamarckii Kiener, 1845 : p. 240.

Genesis

BRUGUIERE (1792 : 706, n° 98) described *C. luzonicus* for which Hwass had given two latin diagnosis whose proposed translations are :

1) - "Cone, whitish shell, dark-brown fasciae interrupted by lines which are punctated with milky coloured, like arrowheads formed spots ; spire convex and mucronate."

2) - "Cone, withish shell, stained with series of bands by "arrowheadish" and nebulous tawny spots ; spire obtuse, aperture bluish."

Only the first "variety" has been figured in the Tableau Encyclopédique (Pl. 338, fig. 6) the figure of which was designated by KOHN (1968) as representative of the holotype of *C. luzonicus*. This taxon has been diversely interpreted by successive authors :

KIENER (1845, Pl. 83 fig. 3) seems to have only reproduced the figure of the Tableau, with some "ameliorations" and had considered it as a synonym of *C. portoricanus* Hwass in Bruguière (1792 : 714, n° 1107 ; Tableau Pl. 338, fig. 4).

Successively REEVE (1844), CROSSE (1858) and WEINKAUFF (1873) considered *C. luzonicus* as a nomen dubium.

KOHN (1968 : 465) synonymised it with *C. testudinarius* Hwass in Bruguière (= *C. ermineus*) as well as *C. portoricanus* (1968 : 756), followed by VINK (1989, II : 7) who considered it as a juvenile and still granulose specimen of *C. ermineus*.

Hwass's second "variety" has been reconsidered by LAMARCK (1822 : 497, n° 118 [b] as his own "variety[b]" of *C. luzonicus* a specimen of which he possessed in his own collection. KIENER (1845 : 240, Pl. 83, fig. 4) seems to be the first one to distinguish this *Conus*, which he called "Cône de Lamarck" or *C. lamarckii* as a species separated from *C. luzonicus*. MERMOD (1947) states that the shell figured by Kiener, and which is kept in the M.H.N.G. in Geneva (N° 1105/87), holotype of *C. lamarckii*, is also the type of Lamarck's *C. luzonicus* "var. [b] (Fig. 8). Thus the synonymy between both taxa is objective.

Kiener's diagnosis (translated from latin) is: "Cone, turbinate shell, thick, swollen towards the upper part, tawny with two fasciae, whitish reticulated dots, spire rounded, obtuse and mucronate with a decurrent excavation, white dashed."

Some precisions are brought in the description : "the spire counts six whorls which are marked below the suture with a superficial decurrent groove, and the spire, of a deeper colouration, is marked with brown and white blotches". Kiener adds : "nice species which was confused by Lamarck with the *Conus luzonicus*, and constituting his variety b. But it is enough to glance over the figures which represent both species to ascertain the differences of their forms or of their colouration."

A superficial examination is sufficient to be convinced that the holotype of *C. lamarckii* also belongs to the variability of *C. guinaicus*, and has very little to do with the *Conus* usually called *lamarckii* (auctorum = *C. cacao* Ferrario) in the literature or even in Museums.

A second and more careful examination and a comparison with series of *C. guinaicus* constrain to identify it as a variant of this species which could be placed at halfway between the phenotype "var.b" of Hwass and the phenotype *C. franciscanus*. Also here the morphological differences are only restricted to the colour pattern of the shell, and its morphometric parameters (see tables) fall in the range of those of *C. guinaicus*. A similar shell was figured by WALLS (1979 : 648, above left) with the erroneous label "*C. taslei*", which is another species. A shell with a similar pattern is shown in our Figs. 7 a and 9.

From these conclusions ensues that C. lamarckii auctorum (non Kiener) remained during a long time without a valid name before Ferrario described it as Conus cacao.

COMPARISONS:

The morphological and morphometric differences between *C. cacao* and *C. guinaicus* are easy to establish. For a long time, it was also considered as a "variety" of *C. mercator* (KAICHER, 1977, III, Card 1250 ; CLOVER, 1978 : 18 ; WALLS, 1979 : 453 below right (?) ; KORN, 1988 : 25, etc...). Some other authors held it as a separate species but with the name "*C. lamarckii*". PIN (1989) established the differences between all these Senegalese *Conus* on basis of their "anal channel", which is strongly tinged with violet in *C. cacao* and pure white in *C. mercator*. (See fig. B).

The Comparison Tables and Graphs will convince better than long sentences.

GEOGRAPHICAL DISTRIBUTION

(See Fig. A). : *C. guinaicus* is commonly distributed along the West-African coasts, from Mauritania to Sierra Leone. It also lives in the Canary Islands.

The normal distribution range of *C. cacao* is restricted along the "Petite Côte", the part of the Senegalese coast between Yenne (northern) and Banjul (southern, Gambia). Some specimens were collected more southern, in Casamance, near Djembering and Kabrousse, which appears the extreme limit of the distribution range of *C. cacao*.

The range of *C. mercator* runs around the Cap Vert peninsula, from Yoff (northern) to Bel Air (southern), including Gorée Island.

C. mercator and *C. cacao* live allopatric. The first one habits in sandy bottom under rock falls, whereas the second is always associated with algae substrates.

CONCLUSIONS:

There are 17 morphological characters which distinct *C. cacao* from *C. guinaicus*, and 13 other ones which distinct it from *C. mercator*. Their morphometric parameters also confirm these differences, as shown in our table. Consequently, *C. cacao* is to be considered as a valid species.

C. franciscanus Hwass, as well as *C. lamarckii* Kiener should be considered only as colour variants of the species *C. guinaicus* Hwass.

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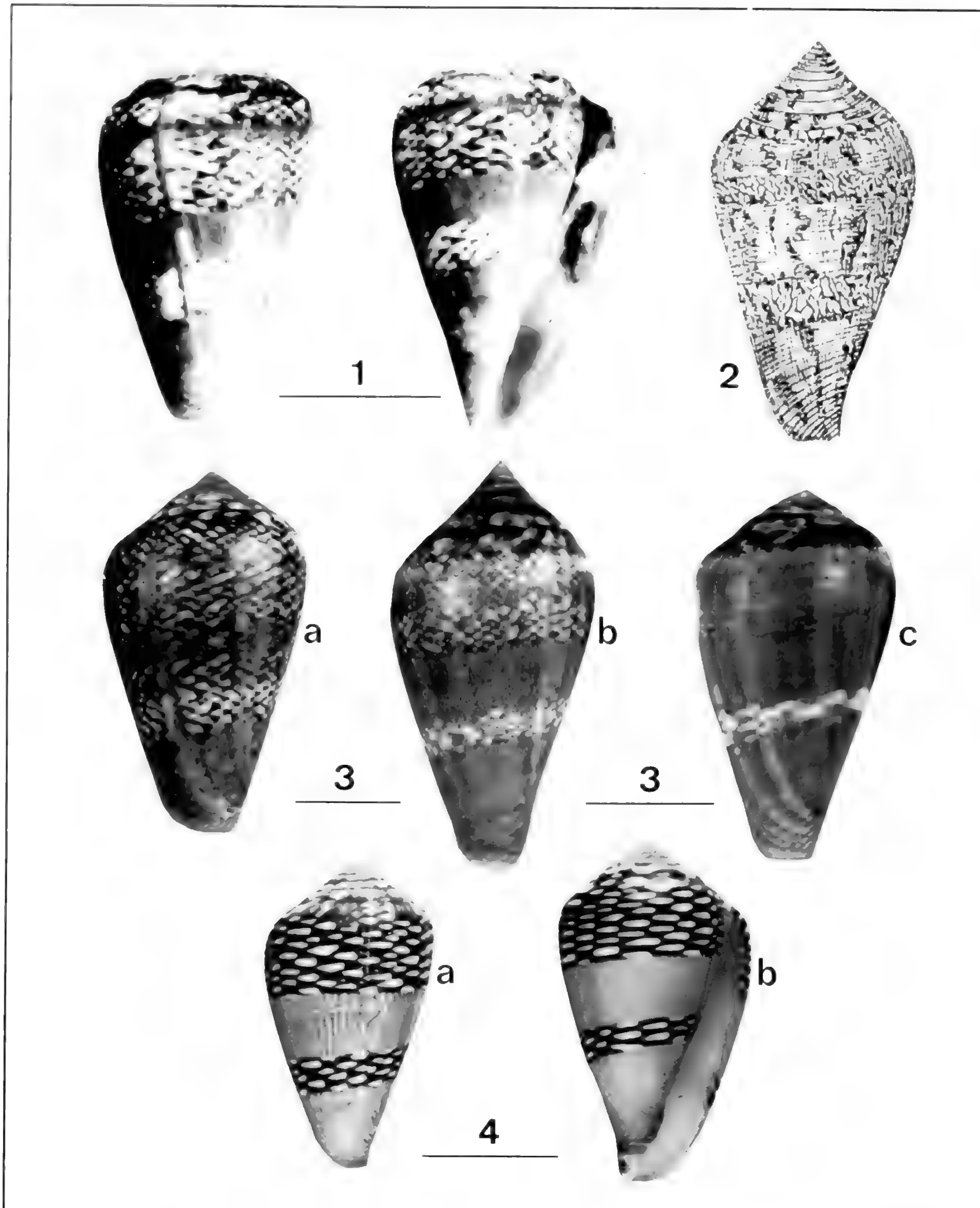


Fig.1 - *Conus cacao* - lectotype, M.N.H.N. Paris - 36.5 x 20.9 mm. dorsal and apertural views (Phot.Lauer)
Fig.2 - *Conus guinaicus* var.A.,in"Tableau",Pl.337,Fig.4. (to compare with Fig.3b)
Fig.3 - *Conus cacao* - Variability - Petite côte, Senegal - a)32 mm - b)36.3 mm - c)33 mm.(Phot.& coll. Lauer)
Fig.4 - *Conus mercator* - N'Gor, Sénégal - a)41.8 mm - b)46 mm.(Phot.& coll. Lauer)

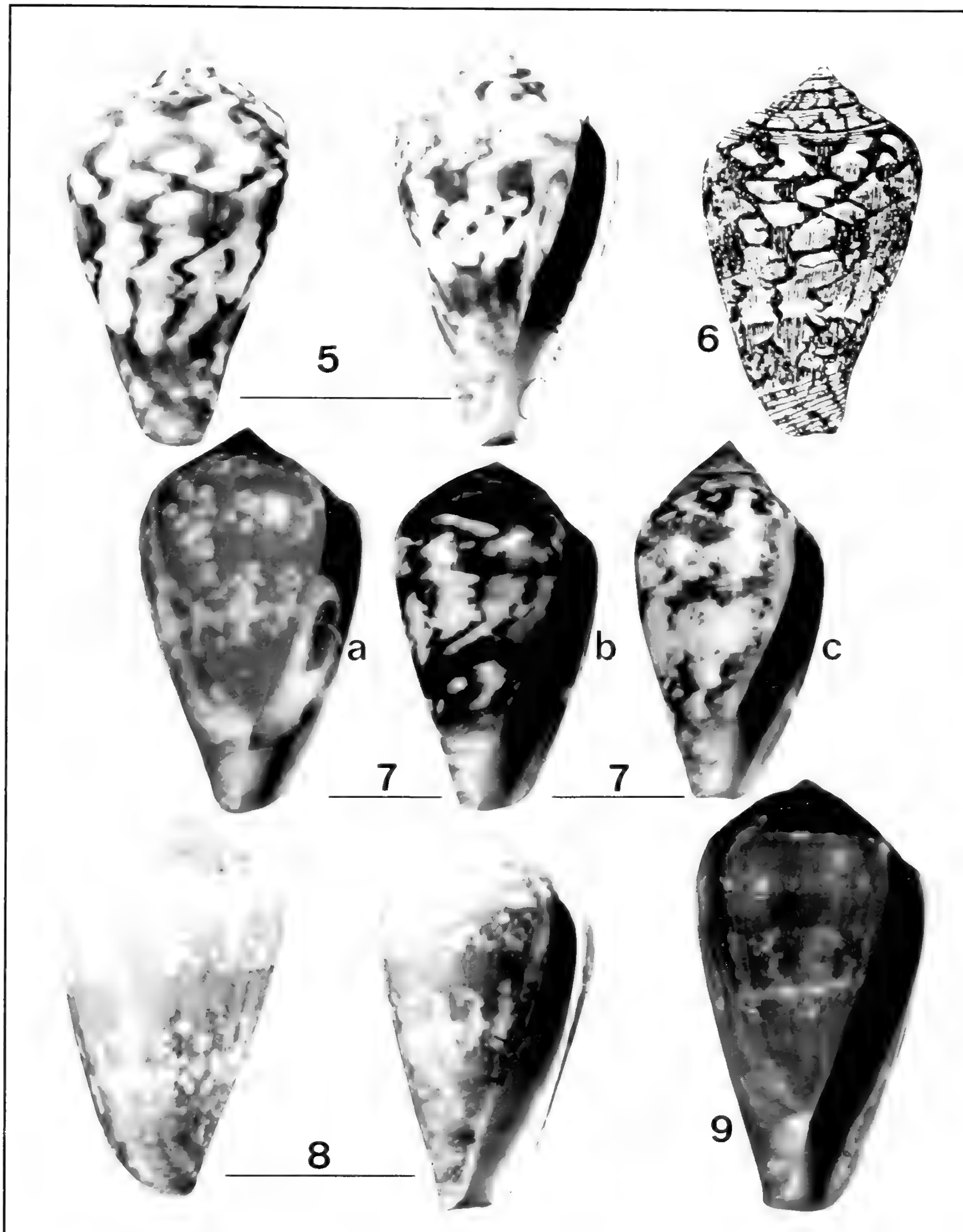


Fig.5 - *Conus guinaicus* - lectotype M.H.N.Genova. - 55.5 x 25.5 mm. (Phot.Dajoz, M.H.N.G.)
Fig.6 - *Conus guinaicus* var.C,in "Tableau",Pl. 337, Fig.6
Fig.7 - *Conus guinaicus* - Variability - Popenguine, Senegal - a)47 mm b)44.1 mm - c)M'Bour, Sénégal:43.4 mm. (Phot.& coll. Lauer)
Fig.8 - *Conus lamarckii* - holotype M.H.N.Genova. - 39.5 x 19.7 mm (Phot.Dajoz, M.H.N.G.)
Fig.9 - *Conus guinaicus* f.*lamarckii* - "homeotype"(*) Petite Côte, Senegal, 44.7 mm.(Phot.& coll.Lauer)

* The term "homeotype is here used to indicate a specimen which closely matches with de type of the species.

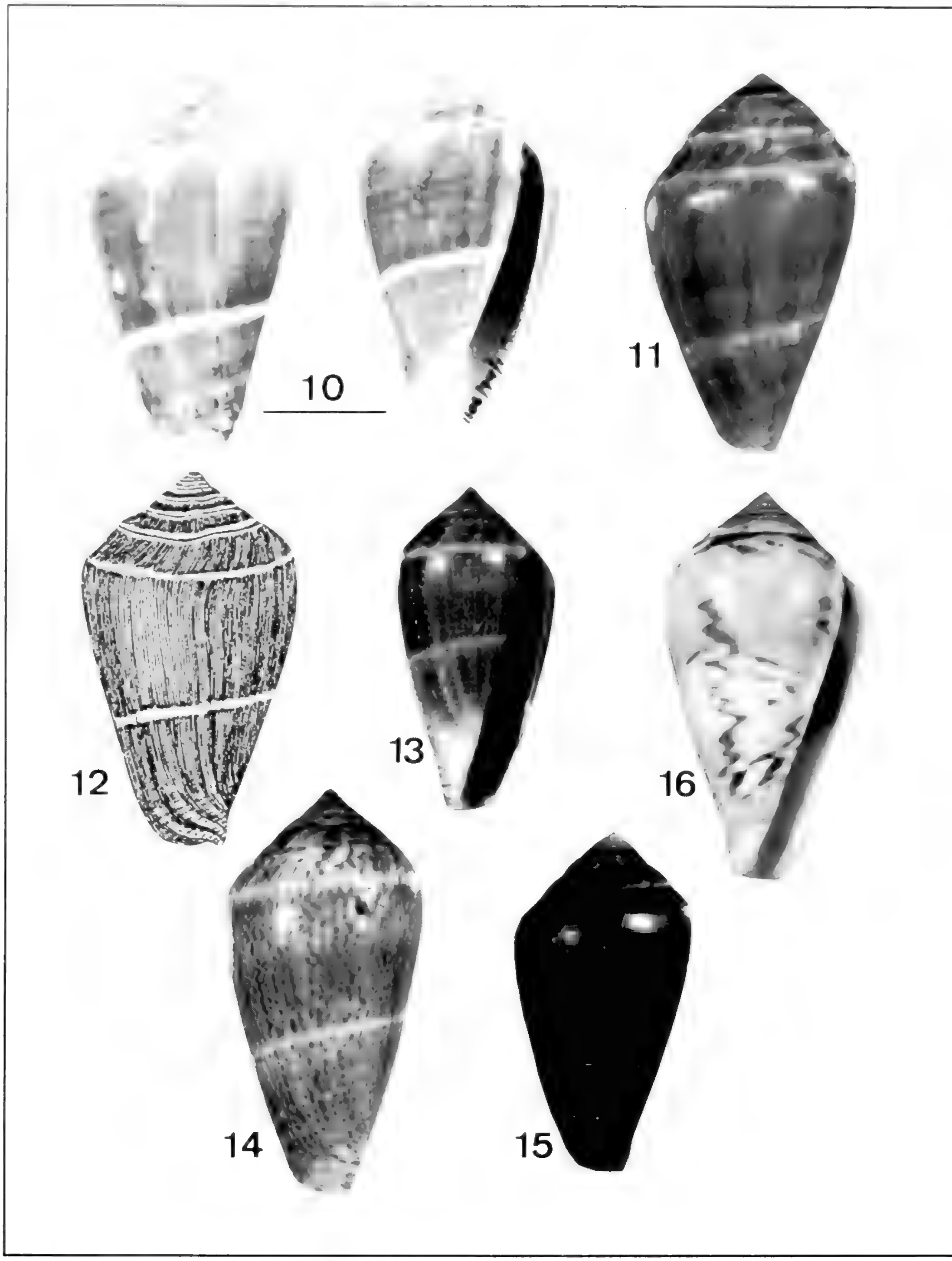
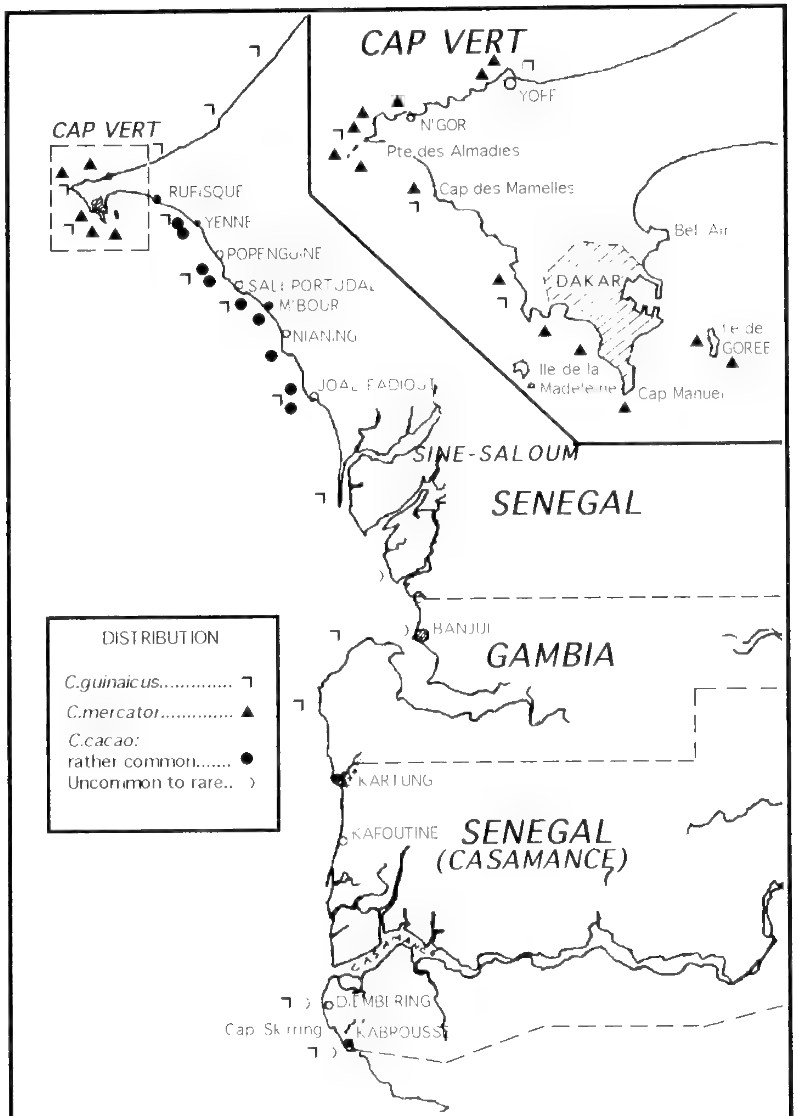


Fig.10 - *Conus franciscanus* - lectotype - M.H.N.Genova, 55 x 30.5 mm. (Phot.Dajoz)
Fig.11 - *Conus guinaicus* f.*franciscanus* - homeotype(*) - Petite Côte, Senegal - 40.9 mm. (Phot.& coll.Lauer)
Fig.12 - *Conus franciscanus* in "Tableau",Pl.337,F.5.
Fig.13 - *Conus adansonii* "f.*franciscanus*" - N'Gor, Senegal 40.5 mm.(Phot.& coll.Lauer)
Fig.14 - *Conus adansonii* "f.*franciscanus*" - N'Gor, Senegal 46 mm.(Phot.& coll.Lauer)
Fig.15 - *Conus aemulus* "f.*franciscanus*" - Angola 33.5 mm.(Phot.& coll.Lauer)
Fig.16 - *Conus species* aff.*mercator* - N'Gor, Senegal 32.3 mm.(Phot.& coll.Lauer)

* The term "homeotype" is here used to indicate a specimen which closely matches with de type of the species.



Distribution map of *C.guinaicus, C.mercator and C.cacao*

TABLE 1 - MORPHOLOGICAL COMPARISONS

CHARACTERS	*Conus guinaicus*	*Conus cacao*	*Conus mercator*
PROTOCONCH	white, always more or less strongly eroded. Number of whorls hard to establish.	white, always strongly eroded. Number of whorls hard to establish.	of paucispiral type, mostly eroded. 1.5 to 1.7 larval whorls.
SPIRE	from 7 to 8.7 (Mean 7.8)spire whorls . Sides straight to slightly convexe. Whorls nearly flat to convexe, the last one being depressed in its middle.	from 7 to 8.3 (Mean 7.8) spire whorls. Sides usually concave in mature specimens, sometimes straight or even convexe in juvenile ones. Whorls flat, the upper part of the last whorl being convexe and rounded.	from 7 to 9.7 (Mean 8.6) postnuclear whorls . From straight to slightly convexe or slightly concave sides. Usually convexe in juveniles. Whorls convexe.
SPIRE SCULPTURES	very fine radial striae; from 4 to 7 fine spiral grooves, sometimes obsolete	fine radial striae; 4 to 5 spiral grooves, only visible on the two last whorls, the other being to strongly eroded	fine radial striae. 3 spiral grooves, principally visible on the last whorl.
SPIRE SUTURE	somewhat irregular, the upper edge of the whorls overlapping slightly the base of the preceding ones	rather regular and linear	linear.
SHOULDER	rounded with a very weak subangulation.	rounded without subangulation.	rounded without subangulation.
BODY WHORL	Swollen, smooth and moderately glossy. Fine axial and very faint spiral striae Base: 10 to 12 weak undulating and near flat ridges	sides from moderately swollen to nearly straight. Smooth and satiny fine axial and very faint spiral striae. Base: 8 to 10 more or less varicose flat costulations	moderately swollen, sometimes nearly straight sides. Very fine axial striae. Base: 7 to 9 more or less varicose and weak costulations.
COLUMELLAR FOLD	fine flat to somewhat twisted, of white to yellowish colour	moderately strong, nearly straight, grayish with a browm marking near the base	strong, pure white, nearly straight.
APERTURE	rather wide enlarging towards the base	moderately wide, lip nearly parallele to the columella.	moderately wide, slightly enlarging towards the base.
LIP	fine and sharp. Origin prolonging the apical angle and showing a median concavity which is characteristic in *C guinaicus*.	fine and sharp. Origin generally prolonging the apical angle, often more elevate than the side of this angle. Rounded, without a median depression	fine and sharp. Origin: prolonging the apical angle sides, rounded without a depression.
COLOUR PATTERNS Spire	Earlier whorls white to tawnish with an upper chestnut border Multiform chestnut to chocolate brown dashes on a white background	Earlier whorls eroded and whitish with an upper brown to blackish border. Small elongate white spots on a dark brown background.	Earlier whorls mostly eroded. Further ones sprinkled with reddish-brown dashes on a white background Following whorls with somewhat lanceolate white dashes with brown outlines.
Body whorl	Whitish background, often suffused with pale bluish to geenish tones. Pattern of close axial lines, whose colour varies between yellowish ochre and dark or even blackish brown Presence of a median fascia of whitish dashes, generally lanceolate and spirally elongate. Two other occasional fasciès of smaller dashes are localized below the shoulder and towards the base Great variability of the patterns, the one of the lectotype being rather uncommon.	Olive-greenish background. Pattern of very fine and close chestnut to reddish-brown axial lines Usual pattern: three fasciae of lanceolate white and close spots of variable width. The variability concerns essentially the general colouration (from deep to light), and the width of the fasciès. Reduced patterns show only a small whitish band on their median.	Pure white background. Axial orange-ochre to light chest-nut close axial lines. Usual pattern: a wide fascia of spirally elongate lanceolate white dashes outlined with deep chocolate-brown, and whish covers from 1/3 to 1/2 of the anterior part of the body whorl. A second, smaller fascie with the same ornamentation is placed slightly below the midbody The variability concerns the width of the fascies, the more or less strong elongation of their white dashes and their dimensions.

Aperture	Tinget of tawnish brown with two small whitish bands directly below the shoulder and slightly below the midbody. The white colour of the hypostracum may be shaded of bluish gray.	Tinget of dark violet to chestnut brown. The edge of the lip is inside sometimes bordered with orange fawn. Two whitish small bands below the shoulder and slightly below the midbody.	Pure white. Some varieties showing dark blotches inside the aperture need further investigations concerning their specific belonging. These forms may show very large and distorted dashes on a white to grayish or greenish background.

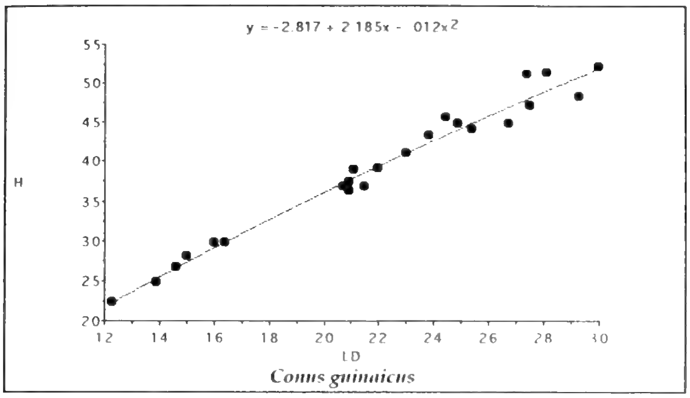
TABLE 2 - MORPHOMETRIC COMPARISONS

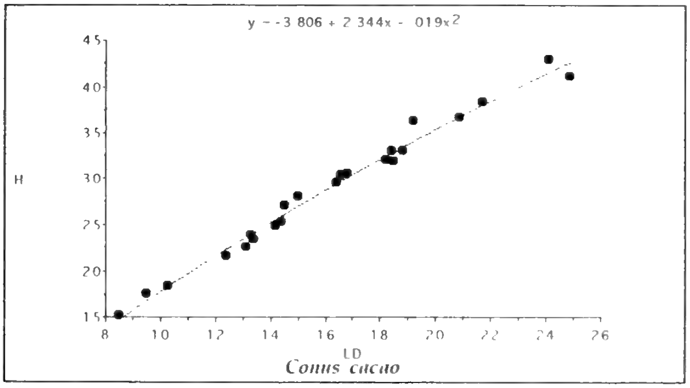
The samplings include specimens from subadult to adult stages (growth series)

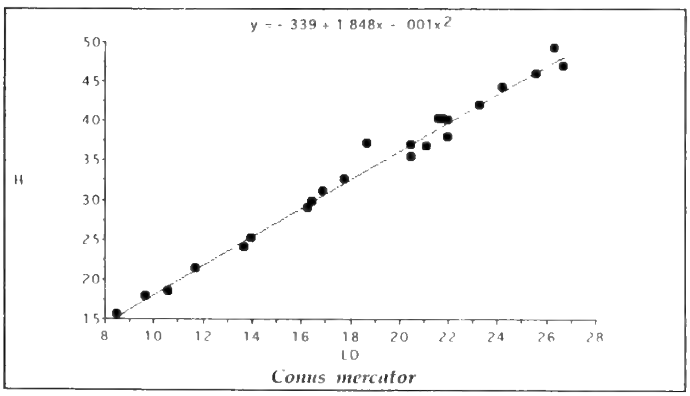
		C.guinaicus	*C.cacao*	*C.mercator*
H **HEIGHT of the SHELL**	Minimum	22.3	15.2	15.6
	Maximum	52.2	42.9	49.3
	MEAN	39.14	28.83	33.81
	Stand deviation	8.89	7.45	9.79
	Variation Coef.	22.71 %	25.83 %	28.95 %
	Confid Interval 95 %	22.4 > < 56.9	13.9 > < 43.7	14.2 > < 53.4
LD **LARGEST DIAMETER**	Minimum	12.3	8.5	8.5
	Maximum	30	24.9	26.7
	MEAN	22	16.22	18.7
	Stand deviation	5.23	4.33	5.34
	Variation Coef.	23.78 %	26.67 %	28.72 %
B **HEIGHT of the BODY WHORL**	Minimum	17.4	12.1	12.1
	Maximum	41.3	36.3	40.8
	MEAN	31.9	24.36	28.41
	Stand deviation	7.48	6.58	8.29
	Variation Coef	24.44 %	27.02 %	29.18 %
S **HEIGHT of the SPIRE**	Minimum	4.3	2.2	2.9
	Maximum	11.5	7.3	10.1
	MEAN	7.24	4.48	5.4
	Stand deviation	1.91	1.28	1.91
	Variation Coef.	26.39 %	28.57 %	35.29 %
AA° **APICAL ANGLE** **(in degrees)**	Minimum	87	88	86
	Maximum	112	123	118
	MEAN	99	105.8	104.7
	Stand.deviation	7.19	9.17	9.57
	Variation Coef.	7.26 %	8.67 %	9.14 %
	Confid Interval 95 %	84.6 > < 113.4	87.5 > < 126.1	85.5 > < 123.8
W **WEIGHT** **(in gramms)**	Minimum	1.3	0.65	0.52
	Maximum	17.78	10.6	12.89
	MEAN	7.92	3.71	5.86
	Stand deviation	4.79	2.69	3.96
	Variation Coef.	60.44 %	71.93 %	67.58 %

		C.guinaicus	*C.cacao*	*C.mercator*
H/LD	Minimum	1.65	1.65	[illegible]
	Maximum	1.87	1.89	1.99
	MEAN	1.79	1.78	1.89
	Stand deviation	0.06	0.06	0.06
	Variation Coef	3.42 %	3.12 %	3.20 %
RSH **RELATIVE SPIRE HEIGHT** **(S/H)**	Minimum	0.14	0.1	0.11
	Maximum	0.25	0.2	0.22
	MEAN	0.19	0.16	0.16
	Stand deviation	0.03	0.03	0.03
	Variation Coef	15.61 %	20.04 %	19.93 %
RD **RELATIVE DIAMETER of the BODY WHORL** **(LD/B)**	Minimum	0.65	0.63	0.63
	Maximum	0.75	0.72	0.7
	MEAN	0.69	0.67	0.66
	Stand deviation	0.02	0.023	0.016
	Variation Coef	3.48 %	3.47 %	2.46 %
W/H **RELATIVE WEIGHT**	Minimum	0.06	0.04	0.03
	Maximum	0.34	0.23	0.28
	MEAN	0.18	0.12	0.15
	Stand deviation	0.08	0.06	0.07
	Variation Coef	44.18 %	48.09 %	49.95 %
RWE **RELATIVE WHORL EXPANSION** **(LD/SD)**	Minimum	1.11	1.15	1.16
	Maximum	1.21	1.26	1.21
	MEAN	1.17	1.19	1.18
	Stand deviation	0.02	0.03	0.01
	Variation Coef.	1.83 %	2.26 %	1.30 %
AE **APERTURE EXPANSION** **(AW/B)**	Minimum	0.06	0.09	0.09
	Maximum	0.12	0.15	0.12
	MEAN	0.1	0.12	0.1
	Stand deviation	0.01	0.01	0.01
	Variation Coef	10.98 %	13.50 %	8.71 %
RBA° **RELAT.BASAL ANGLE**	Minimum	24.2	20.4	22.4
	Maximum	38.1	33.6	32.3
	MEAN	29.9	27.6	27.7
	Stand deviation	3.46	3.53	2.71
	Variation Coef	11.58 %	12.80 %	9.80 %
RSA° **RELAT.SPIRAL ANGLE**	Minimum	109.6	106.2	107.5
	Maximum	123.7	122.3	122.4
	MEAN	115.6	113.3	113.8
	Stand deviation	3.59	4.37	4.38
	Variation Coef	3.10 %	3.86 %	3.85 %

GRAPHS I - POLINOMIAL REGRESSION of H vs LD







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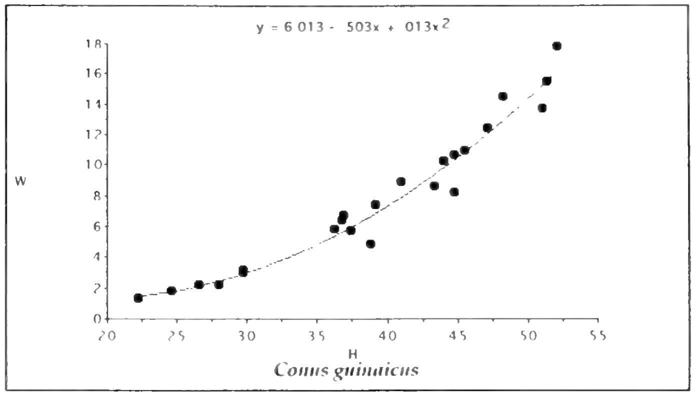
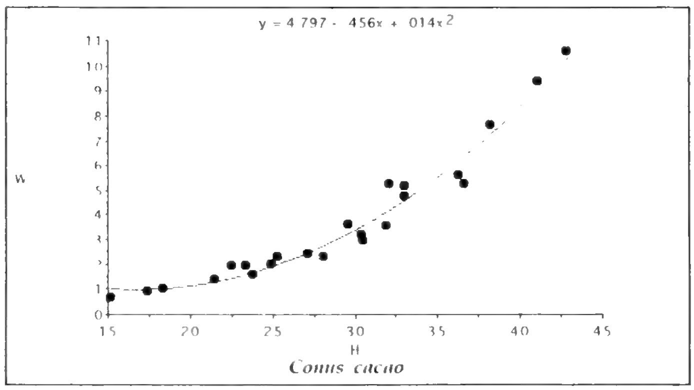
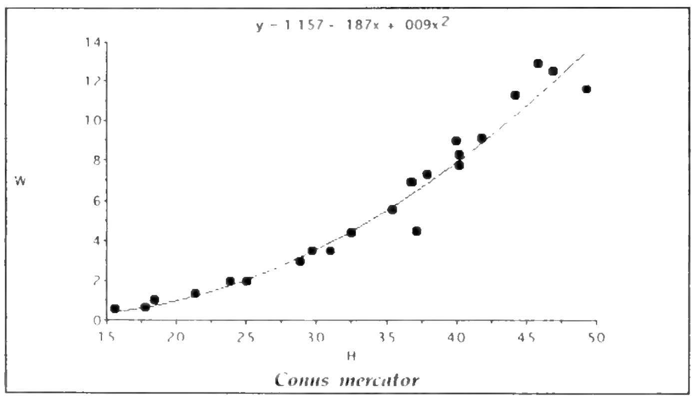
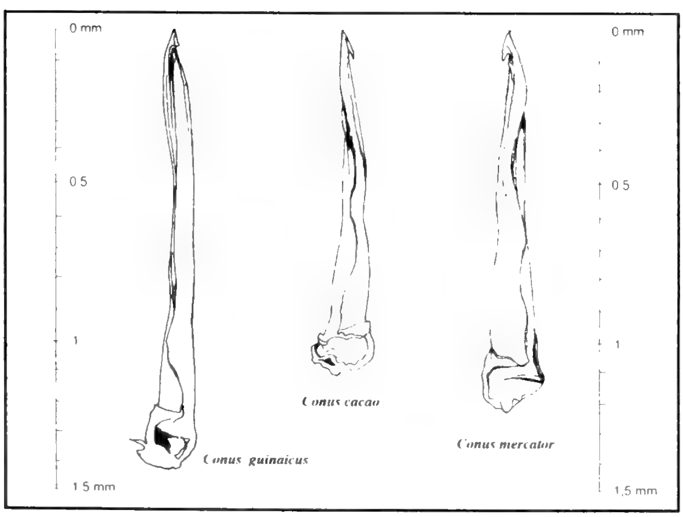
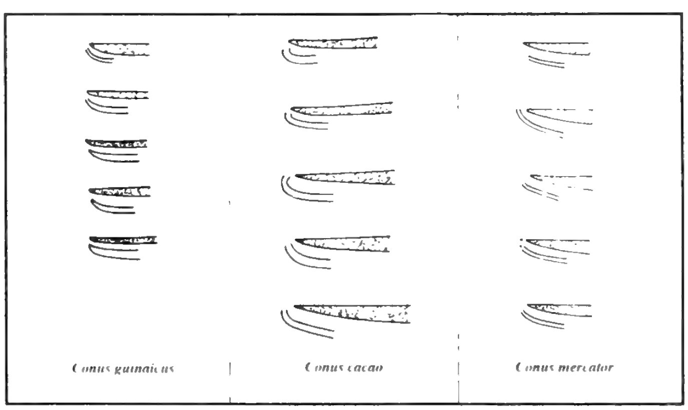








RADULAR TEETH of *C.guinaicus*, *C.cacao* and *C.mercator*



COMPARISON TABLE OF THE " ANAL CHANNELS " in *C.guinaicus*, *C.cacao* and *C.mercator* (after PIN (1989) Scale x 2)

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Egg variability and the reproductive strategy of *Pomacea canaliculata* (Gastropoda: Ampullariidae) *

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ABSTRACT: The variation in egg size among populations of *Pomacea canaliculata* (Lamarck, 1822) was studied. Significant differences were found among egg clutches from the same population, but not among populations. Some females lay eggs of different sizes in the laboratory. Repetitive spawning after a single mating indicates that females are able to store active sperms for more than a month. No significant correlation between the isolation time and clutch size was found. Observation of two cohorts maintained in the laboratory for about four years revealed that the species is iteroparous when reared at variable temperature. The values obtained for the reproductive effort in *P. canaliculata* appear to be higher than those for other iteroparous gastropod species.

INTRODUCTION

The egg clutches of most species within the genus *Pomacea* Perry, 1810 are reddish and are deposited aerially. Some intra- and interpopulation variability in egg size and colour, clutch size, etc., has already been suggested. D'ORBIGNY (1849) noted that *Pomacea canaliculata* (Lamarck, 1822) lays eggs of smaller diameter than those of the closely related species *Pomacea insularum* (d'Orbigny, 1835). BACHMANN (1960) agreed that a difference exists, but assigned the smaller eggs to the latter species: 2.5 mm in *P. insularum* and 3.0 mm in *P. canaliculata*. No statistically useful data were however presented in either publication. We hypothesize that these differences would fit into the natural range of variation of the eggs of *P. canaliculata*, one of the most widespread species of this group (CAZZANIGA, 1987), due to its adaptability to different environments.

There are few studies on the reproductive strategy of this gastropod family. BACHMANN (1960) stated that *P. canaliculata* has a life span of three years, with only one reproductive season. From a theoretical standpoint, semelparity is less probable than iteroparity in freshwater snails whose life cycles are longer than one year (BROWNE and RUSSELL HUNTER, 1978; CALOW, 1978). Bachmann's preliminary assertion thus required further investigation.

The aim of this paper is to describe the variability of egg size in *Pomacea canaliculata* and to carry out a preliminary analysis of the reproductive effort of this species as a contribution towards an assessment of its life cycle strategy.

* Contribution # 26 of the Laboratorio de Ecología Acuática, Departamento de Biología, U.N.S.

** Researcher of the Comisión de Investigaciones Científicas de la Provincia de Buenos Aires.

MATERIAL AND METHODS

Egg clutches of *Pomacea canaliculata* were obtained from the sites detailed in table 1. Laguna Alsina is a mesohaline Pampean third-order lake of 42 km²; its limnological characteristics have been described and discussed by RINGUELET (1972). Laguna La Larga is a permanent, small pond of less than 0.5 km², and La Manuela farm pond is actually a very small depression filled by rain water; both are located in the Puan district. Great part of their surface is covered by rushes (*Scirpus californicus*), and the water level is very variable. No limnological information is available on these two ponds. The other three pools mentioned in table 1 are located within urban parks in the cities of Buenos Aires and La Plata. Since they are regulated, their conditions vary widely as a result of intentional drainage, summer evaporation and rain dilution. These pools are usually invaded by submersed vegetation, mainly *Myriophyllum elatinoides* and *Elodea* sp.

After dissociation of the clutch in water, twenty randomly selected eggs from each egg mass were measured under micrometric ocular. The variability was analyzed by means of nested ANOVA.

From two strains reared at variable room temperature in the laboratory and fed on lettuce, the number of snails born during each reproductive season was recorded over three years. The cohorts started with 243 and 244 newly hatched snails, respectively, from single clutches. These same two strains were designated cohorts A and B in a previous paper (ESTEBENET and CAZZANIGA, 1992), where more details on the rearing conditions are given.

As the snails grew, they were transferred to aquaria of increasing capacity (10, 20, and 45 l) in order to minimalize the crowding effects on growth and survival (CAZZANIGA and ESTEBENET, 1988).

Twelve females were randomly selected from a breeding aquarium and isolated separately in 3 l pots to record the number of egg clutches produced without new matings. In each case, the number of eggs per clutch, the number of surviving offspring, the developmental time, the size of the newly hatched snails and the percentage of viable eggs were recorded.

The reproductive effort was estimated by the indirect effort index (IEI), as defined by CALOW (1978):

$$IEI = E \times EV / SV$$

where E = egg number in a reproductive period; EV = individual egg volume, and SV = parent's volume. IEI assumes that energy loss per egg is proportional to egg volume and that the demand egg production makes on the parent is roughly proportional to the relative mass of the adult and the total number of eggs spawned.

CALOW (1978) also defines a direct index of reproductive effort based on caloric values, which should be more accurate from an evolutionary point of view. However, the indirect estimate remains viable when no information on egg energetic content is available.

The volume of the females was estimated by means of a cone model (vol.$=1/3\pi(W/2)^2L$, where W = shell width and L = shell length), which gave no significant differences vis-à-vis the actual volumes measured by water displacement of ten specimens ($t = 0.38$, d.f. = 8). Egg volumes were estimated on the basis of the length of newly hatched snails using a sphere model (vol. $= 4/3\pi(L/2)^3$, where L = the mean offspring length within each clutch of every female). Birth occurs by mechanical fracture of the egg shell, at which stage the length of the newly hatched snail almost equals the diameter of the egg. This procedure permitted the simultaneous assessment of viability and size variability among egg clutches of a same female, using one way ANOVA for the latter.

RESULTS

Highly significant differences were detected in egg size among the egg clutches coming from one field population ($p<0.01$), but no difference was evident from one locality

to another (p>0.05) (table 2). The range of egg diameters was 2.24 to 3.47 mm. Additional single egg clutches were collected at Catamarca and Río Segundo, Argentina (January 1984, Cazzaniga col.); their mean egg diameters were 2.34 mm and 2.07 mm, respectively.

The snails of the two laboratory cohorts entered their reproductive phase in month 25, and thereafter the number of newly born snails was recorded monthly. The relevant figures are given in table 3. In month 36 a new reproductive period started, indicating that this species is iteroparous under laboratory conditions. The mean number of eggs per female under these conditions was much lower than the mean clutch size in the field. The egg masses were small and most females did not spawn. In spite of the precautions taken to avoid crowding effects, interference among snails within the aquaria did occur.

A mean viability of 86.44 % (s = 9.1164) was recorded for 45 egg clutches from field and laboratory populations (11,563 eggs). The number of viable offspring is not significantly correlated to the clutch size (r = -0.34; n = 25, p>0.05).

Five of the isolated females laid more than one egg clutch, as recorded in table 4. Since no new matings were allowed, these results prove that the females can reserve active sperms for more than a month.

One of the isolated females spawned 12 times within 41 days. The clutch size bore no correlation to the length of time spent in isolation (Spearman's correlation r_S = -0.21; p>0.05), nor did the number of offspring of isolated females bear any significant correlation to the size of the clutch (r = -0.25; n = 22, p>0.10).

The size differences made apparent by a comparison of the eggs spawned by a same female (table 5) contribute to the intrapopulation variation already pointed out.

The mean reproductive effort of the isolated females, without new copulation (table 6), was IEI = 0.3044 over a 41-day period. Considering a mean adult female, 40 mm long, and a mean egg of 8.47 mm^3, 1,920 eggs must be laid per reproductive season to reach the minimum IEI given by CALOW (1978) for a semelparous species (IEI = 1.23). Since a female can spawn up to ten times or more per summer (BACHMANN, 1960) and the mean number of eggs per clutch is 311.57 ± 192.56 (mean ± standard deviation; n = 67), it is highly probable that the actual value is near IEI = 2. In other words, this species appears to have a greater reproductive effort than other iteroparous gastropods and than many semelparous ones. The effort for a mean egg clutch is IEI = 0.1993. The egg volume/adult volume ratio is about 1:1,500 to 1:3,000, according to the great number of eggs laid per reproductive season.

DISCUSSION

The statement that egg size is a diagnostic feature distinguishing *Pomacea canaliculata* from *P. insularum*, as asserted by BACHMANN (1960), seems unrealistic from the analysis of the egg variability in this study. Egg sizes for populations within the supraspecies *canaliculata* (CAZZANIGA, 1987) widely overlap (table 7). The supposed differences among these sympatric species are indistinguishable from intrapopulation variability, which according to our results exceeds the interpopulation variation. These differences are recorded not only among the eggs laid by different females but also among different egg clutches of the same females. Similarly, SOUZA LOPES (1956) reared *P. canaliculata* in the laboratory, and observed that snails hatched from eggs 2.8-3.0 mm in diameter laid eggs 3.0-3.5 mm in diameter one year later.

The viability value of the eggs spawned by *Pomacea canaliculata* in the present study is high, and is similar to the values obtained by MARTIN (1984) and SANTOS-CARVALHO et al. (1974) for this and other Neotropical ampullariids.

BACHMANN (1960) stated that every egg clutch of *P. canaliculata* requires a new mating. CAZZANIGA and ESTEBENET (1984) cited the laboratory observation of one female

which spawned eight times during two weeks without any new contact with males. Our data from isolated females confirm that this species can repeatedly spawn without new copula, and can store sperm for more than a month. The total number of eggs laid after a single mating is greater than the mean single clutch size recorded for this and related species, leading us to the conclusion that repetitive spawning is a normal mechanism in the natural habitats of this species.

There are reports on repetitive spawning in *P. paludosa* (Reeve) and *Marisa cornuarietis* (L.), both of which continue to lay egg masses for more than a month (DEMIAN and IBRAHIM, 1971; HURDLE, 1973). The bursa copulatrix is the site where sperm is stored (ANDREWS, 1964).

It is worth noting that no significant correlation exists between viability and clutch size for either field or isolated laboratory females. This is in agreement with some raw data presented by MARTIN (1984), from which we calculated a correlation coefficient $r = 0.39$ ($n=22$, $p>0.05$), and would be considered as a common characteristic of this species.

As for the reproductive mode, two types of egg clutches are already known within the genus *Pomacea*. The most common are aerial clutches of numerous small eggs, attached to emergent plants and other objects (SNYDER and SNYDER, 1971), similar to *Pila ampullacea* (L.) and *Pila scutata* (Mousson, 1848) (BENTHEM JUTTING, 1956) and other species. The second mode is that of *Pomacea urceus* (Müller, 1774), which lives in temporary water bodies in northern South America. It lays relatively few giant eggs, which are brooded in an incubation chamber between the mother's operculum and the dry mud (BURKY, 1974; LUM KONG and KENNY, 1989). Several species of *Pila* also aestivate to pass the dry season, but there are no detailed references about their reproductive modes (ARKELL, 1924; NONO and MANE, 1931; MEENAKSHI, 1964; VISSER, 1965; COLES, 1968). All of them are among the largest freshwater snails in the world.

A third reproductive mode is known in the Ampullariidae, whereby the eggs are submerged, do not have a calcareous shell, and are embedded in a gelatinous mass (i.e. genera *Marisa*, *Asolene*, *Lanistes*) (MICHELSON, 1961; DEMIAN and IBRAHIM, 1971); but this mode does not occur in *Pomacea*. The eggs of *Pomacea scalaris* (d'Orbigny, 1835) are not of this type, as was asserted by HYLTON SCOTT (1957) and repeated by SNYDER and SNYDER (1971), but of the aerial type (BONETTO and EZCURRA de DRAGO, 1966).

The reproductive strategy of *P. urceus* is iteroparity. On average, females lay clutches of 125.5 eggs (102-169 eggs) at each reproductive season, which they protect (in an incubation chamber as described above) during the dry season in the Venezuelan savannah. Adults reach a length of up to 118 mm and the average egg diameter is 11.5 mm (6.7-15.5 mm). The brood born in January-February aestivates during 4 months within the mother's chamber and acquires the minimum reproductive size (85 mm long) in November-December, when the next dry season begins (BURKY, 1974). This species is iteroparous, having 2-3 breeding seasons during its life cycle (up to 3.5 years).

On the basis of existing data provided by BURKY (1974), the indirect reproductive effort (Calow's IEI) for an adult female *P. urceus* is IEI = 0.2273 to 0.4656, which falls within the range of values given by CALOW (1978) for iteroparous snails. Our results on *P. canaliculata* show an IEI = 0.30 after a single copulation, i.e. the two species appear to spend equivalent amounts of energy on the eggs produced from one mating. However, the need for incubation during the dry season restricts *P. urceus* to a single brief annual period of egg laying, whereas *P. canaliculata* can continue to reproduce throughout the summer because of the permanency of the water bodies which it inhabits (ponds, rivers and swamps). Iteroparity is the expected strategy in permanent habitats, which are relatively stable

in spite of seasonality (BROWN, 1979). In the temporary waters where *P. urceus* thrives, iteroparity can be maintained through several biological adaptations, i.e. a drastic reduction of fecundity, the production of giant eggs, fast growth and early maturation.

Both *P. urceus* and *P. canaliculata* have long life cycles (more than 3 years), and are iteroparous in regions with hydric and thermal seasonality. BACHMANN (1960) stated that *P. canaliculata* reaches maturity when 2-3 years old in northern Buenos Aires Province. Our cohorts also laid the first viable eggs at the age of two years.

In contrast, the closely related species *P. haustrum* (Reeve, 1856), from Brazil, matures 10 to 17 months after birth, depending on the locality and the breeding conditions (MILWARD de ANDRADE et al., 1978; GUIMARAES, 1981a, 1981b).

The reproductive strategies of the gastropods can, however, vary in different conditions and ecosystems (BOAG and PEARLSTONE, 1979; CALOW, 1981; BROWN et al., 1985; GEBHARDT and RIBI, 1987). Temperature appears to be one of the main factors affecting both the maturation process and the activity of these organisms. When reared at a constant temperature of 25°C, *Pomacea canaliculata* is semelparous and its life span is reduced to less than 14 months (ESTEBENET and CAZZANIGA, 1992).

Whereas in field populations from the Province of Buenos Aires the activity and oviposition period runs only from October to March-April, and the snails hibernate buried in the wet bottom, in Brazil and Paraguay the pomaceas are active throughout the year (HYLTON SCOTT, 1957; MILWARD de ANDRADE et al., 1978).

Unfortunately, no statistics on the number of eggs per female or data on the degree of iteroparity are known for the Brazilian forms. The hypothesis that ampullariids from tropical humid areas without marked seasonality have semelparous or quasi-iteroparous life cycles (CALOW, 1978) therefore remains to be tested.

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Table 1. Sites of collection of the *Pomacea canaliculata* eggs in Buenos Aires Province (Argentina).

Locality		Number of egg clutches	Date	Range of the mean egg diameter (mm)
1. Laguna Alsina	36°23'S-62°13'W	8	Oct. 1984	2.70 - 3.26
2. La Manuela farm pond (Montenegro)	37°24'S-62°40'W	8	Dec. 1986	2.40 - 3.18
3. Laguna La Larga	37°26'S-62°38'W	5	Dec. 1986	2.43 - 3.08
4. Saavedra Park (La Plata city)	34°55'S-57°57'W	4	Feb. 1987	2.51 - 2.95
5. Paseo del Bosque (La Plata city)	34°55'S-57°57'W	4	Feb. 1987	2.45 - 2.93
6. Palermo (Buenos Aires city)	34°35'S-58°29'W	7	Feb. 1988	2.51 - 3.14

Table 2. Nested analysis of variance of the egg sizes of *Pomacea canaliculata* from different localities.

Source	SS	df	MS	F
Among localities	6.141	5	1.228	1.19 NS
Among egg clutches from a same site	30.911	30	1.030	147.14 **
Error	4.759	684	0.007	

NS = $p>0.05$ ** = $p<0.01$

Table 3. Number of snails born from females of *Pomacea canaliculata* reared in laboratory.

Date month/day/year	Age (months)	Females mean length (mm)	Offspring number per female
01/04/87	25	31.60	0.370
02/03/87	26	32.58	5.985
03/02/87	27	33.08	11.618
04/03/87	28	33.64	19.880
1987			37.853
12/03/87	36	35.91	34.930
01/04/88	37	36.70	24.175
02/08/88	38	38.48	44.650
03/06/88	39	39.28	16.775
1988			120.530

Table 4. Egg clutches laid by isolated females of *Pomacea canaliculata* without new matings.

Length (mm)	Number of egg clutches	Time of oviposition *		Total eggs	Egg number by clutch (range)	Viability **	
		1st	last			range	mean
42.0	12	4	41	1119	13-189	69.23-97.35	93.57
52.1	3	5	31	554	26-341	91.98-96.48	94.94
39.8	4	4	13	475	26-208	83.33-96.63	92.84
39.4	4	2	22	387	28-171	89.29-100.00	98.45
47.9	3	5	15	506	95-206	18.95-89.32	74.70

* Days after isolation. ** Born snails/eggs (%).

Table 5. Comparison of the diameter of the eggs laid by single females of *Pomacea canaliculata*.

Specimen	Clutches considered	SS among clutches	SS within clutches	df	F
1	4	127.77	135.79	3 - 77	24.15 **
2	2	4.23	35.75	1 - 38	4.49 *
3	4	42.81	101.44	3 - 72	10.13 **
4	3	2.80	70.85	2 - 57	1.13 NS
5	2	7.23	79.75	1 - 38	3.44 NS

NS = $p>0.05$ * = $p<0.05$ ** = $p<0.01$

Table 6. Reproductive effort of the isolated females *Pomacea canaliculata*.

Specimen	Volume (mm^3)	Mean egg diameter (mm)	Mean egg volume (mm^3)	Number of eggs	IEI
1	15,383.59	2.58	9.1725	1119	0.6672
2	30,002.13	2.65	9.7337	554	0.1710
3	13,020.31	2.37	6.9563	475	0.2538
4	12,618.91	2.47	7.8976	387	0.2422
5	23,122.09	2.54	8.5876	506	0.1879
				Mean =	0.3044

Table 7. Number and size of the eggs laid by closely related species of *Pomacea*, within the supraspecies *canaliculata*.

Species	Eggs/clutch	Diameter		Authority
		Mean	Range	
Pomacea canaliculata	> 100	ca. 2 mm	-	HYLTON SCOTT, 1934
	-	-	2.8-3.5	SOUZA LOPES, 1956
	423.20 (92-790; n=22)	-	2.5-3.5	MARTIN, 1984
	-	3.0 mm	-	BACHMANN, 1960
	311.57 (13-673; n=67)	2.40-3.26 2.07 (Rio Segundo) 2.34 (Catamarca)	2.24-3.47	This paper
Pomacea insularum	-	2.5 mm	-	BACHMANN, 1960
	up to 3,500 (?)	2.5 mm	-	BONETTO and EZCURRA de DRAGO, 1966
Pomacea australis (= *P. canaliculata*)	up to 1,500	3.0 mm	-	BOYER and REY, 1926
Pomacea haustrum	525 (n=8)	2.4 mm	-	FAUSTO FILHO, 1962
	235.7 (n=700)	3.0 mm	2.4-3.5	GUIMARAES, 1981a,b
	209.7 (74-785; n=100)	3.0 mm	-	MILWARD de ANDRADE *et al.*, 1978

Description of two new species of *Amphidromus* from Sumatra, Indonesia (Gastropoda:Pulmonata:Camaenidae)

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KEY-WORDS: Camaenidae, Indonesia, *Amphidromus* n. sp.

INTRODUCTION

In 1986 and 1988, two tree snail species of *Amphidromus s.s.* were collected in Sumatra. The first species differs from other species of *Amphidromus* from Sumatra in having a yellowish-orange band at the apertural edge, and the second in having a purplish dark brown parietal wall. Both of them also are different from several other species of *Amphidromus*; a total of 5 species of *Amphidromus s.s.* are now recorded in Sumatra island, the three other ones are *A. (A.) inversus* Müller, 1774; *A. (A.) palaceus* Mousson, 1848 and *A. (A.) peversus* Linné,1758 (VAN BENTHEM JUTTING, 1959).

Abbreviations

MZB - Museum Zoologicum Bogoriense, Bogor, Indonesia
ZMA - Zoölogisch Museum, Universiteit van Amsterdam, Netherlands
SMF - Forschungsinstitut Senckenberg, Frankfurt, Germany
sin. - sinistral
dex. - dextral

Amphidromus (Amphidromus) djajasasmitai n.sp.

Figs 1,2,3,4.

Material studied. Bengkunat 5° 37' S - 104° 18' E: holotype, MZB no.Gst.9462; 4 paratypes, MZB no.Gst.9463; 2 paratypes, ZMA Moll. no. 3.93.026; 2 paratypes, SMF no. 309926; 3 paratypes, author coll.Marang Ulu 5° 24' S - 104° 4' E: 3 paratypes, MZB no.Gst. 9464. Way Jambu, North of Marang 5° 22' S - 104° 2' E: 3 paratypes, MZB no. Gst.9465. Sumur Tujuh near Kota Agung 5° 28' S - 104° 29' E: 3 paratypes, MZB no. Gst. 9466.

Type locality. Bengkunat, Lampung, Sumatra, Indonesia, 5°37' S - 104°18' E, on tree.

Description. Shell relatively small, up to 42.2 mm; dextral or sinistral; ovate-conical. Rather thin and transparent, smooth, polished.

Shell yellow, sulphur-yellow or greenish-yellow with narrow white subsutural band, becoming broader towards apex. Grey colour occasionally present below subsutural band on several earlier whorls. One or more transparent yellow spiral lines may be present on last and penultimate whorls. Apex white,little obtuse, smooth and shining. Shell without varices; sculptured by fine radial striae and finer spiral striae. Whorls slightly convex, increasing regularly in size; last whorl high, about three quarters of shell height.

Aperture oblique, ovate, somewhat angular at its base, yellowish within. Yellowish-orange band at apertural edge and through outside. Peristome white, narrowly expanded, outer lip thickened, recurved. Parietal wall covered by thin translucent callus;usually thickened white at two ends, occasionally at margin. Columella vertical, rather thin and sharp. Umbilicus

closed; covered by thickened white, broadened and slightly twisted columellar side.

Dimensions: see table 1.

Distribution. Known only from some localities in Lampung Province, South of Sumatra. All material studied taken from relatively near sea level. Collected in the field, number of dextral and sinistral specimens relatively balanced with little dominant of sinistral forms from Bengkunat.

Habitat. Living on trees, at Way Jambu on coffee trees. Animal buff tawny, with purplish-grey or brownish-grey tentacles and head, foot fringe white.

Remarks. Distinctive characters of *Amphidromus djajasasmitai* are: small for the subgenus, amphidromine, yellow shell without varices, recurved lip, closed umbilicus type, last whorl high with yellowish-orange band at apertural edge.

Amphidromus alticola Fulton, 1896 may be confused with *A.djajasasmitai*, but *A.alticola* has a comparatively more thin shell; thin lip, not or very little reflected and no yellowish-orange band at its apertural edge. *A.alticola* lives in mountains of West Java, 1400-2000 m (VAN BENTHEM JUTTING, 1949-1950), and hasn't been recorded in Sumatra. *A. djajasasmitai* lives in Lampung Province, South of Sumatra.

Amphidromus palaceus var. *tener* Martens, 1867 from West Java and *A.peversus peversus* Linné, 1758 from Sumatra, Java, Borneo, Celebes, Bali, in some their satellite islands are quite similar to *A. djajasasmitai*. Generally, they are different in having a larger, white callus, and no yellowish-orange band at the apertural edge. *A. palaceus* var.*tener* has a perforate or closed umbilicus and stronger radial striae. *A. peversus peversus* is thicker than *A. djajasasmitai*, has no white subsutural band and usually has a white aperture, a varix on the last or penultimate whorl, a black-brown edge behind the peristome and adnate outer lip.

Etymology. The species is named in honour of Mr. Machfudz Djajasasmita, Museum Zoologicum Bogoriense, Bogor, Indonesia.

Amphidromus (Amphidromus) puspae n.sp.

Figs 7,8,9,10.

Material studied. Rengas Ulu, Bangko: holotype, MZB no. Gst. 9467; 1 paratype, ZMA Moll. no. 3.93.027; 1 paratype, SMF no. 309927.

Type locality. Rengas Ulu, Bangko, Jambi, Sumatra, Indonesia, on tree.

Description. Shell moderately large, up to 59.4 mm; dextral or sinistral; high-conical.Thick, little or not transparent,smooth and polished.

Shell greenish-yellow or straw colour; later whorls ornated with irregular spaced radial brown and light brown lines,reaching the suture. Apex yellow, smooth and shining; earlier whorls yellow, paler below;white subsutural zone on later whorls. Whorls slightly convex, increasing regularly in size. Fine radial striae and weak spiral striae.

Aperture oblique, ovate, yellowish-white within. Parietal wall brown or purplish-brown, overlaid by darker marginal callus. Peristome white, thickened, expanded and little reflected. Columella vertical, dull brownish-purple externally around lower half of last whorl. Umbilicus closed or nearly closed.

Dimensions: see table 2.

Distribution. Known only from Rengas Ulu, Bangko, Jambi Province in Mid Sumatra.

Habitat. Living on trees, holotype on rubber tree.

Remarks. Other large and high-conical *Amphidromus* that resemble *Amphidromus puspae*, are the yellow *A.javanicus* Sowerby, 1841 from West Java, and *A.inversus inversus* Müller, 1774 from Malaya, Sumatra, some satellite islands are north of West Java. They are different in having a dull surface, and radial streaks or bars compared to the radial lines in *Amphidromus puspae*. *A. javanicus* has a white parietal callus and coarser radial striae. *A.inversus inversus* has a brown edged outer lip, a darker colour below the periphery, a light zone around the umbilicus and a dark brown parietal wall overlaid by a white marginal callus.

With their purplish-black parietal wall *A. janus* Pfeiffer, 1854, from Mergui Islands (Burma) and *A.atricallosus atricallosus* Gould, 1843 from Burma, Thailand, Malaya (LAIDLAW & SOLEM, 1961) are rather close to *A. puspae*. *Amphidromus janus* is smaller, the colour pattern is spirally oriented, while *A. atricallosus atricallosus* has more convex whorls and usually has one or more dark varices.

Etymology. Named for my wife, Puspa.

Acknowledgements

My sincere thanks to Mr.Machfudz Djajasasmita and Mr. Roland Houart, for their suggestions, corrections and comments on the manuscript.

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Table 1. *Amphidromus (Amphidromus) djajasasmitai* n.sp. Size variation in 21 specimens. (11 sin., 10 dex.)

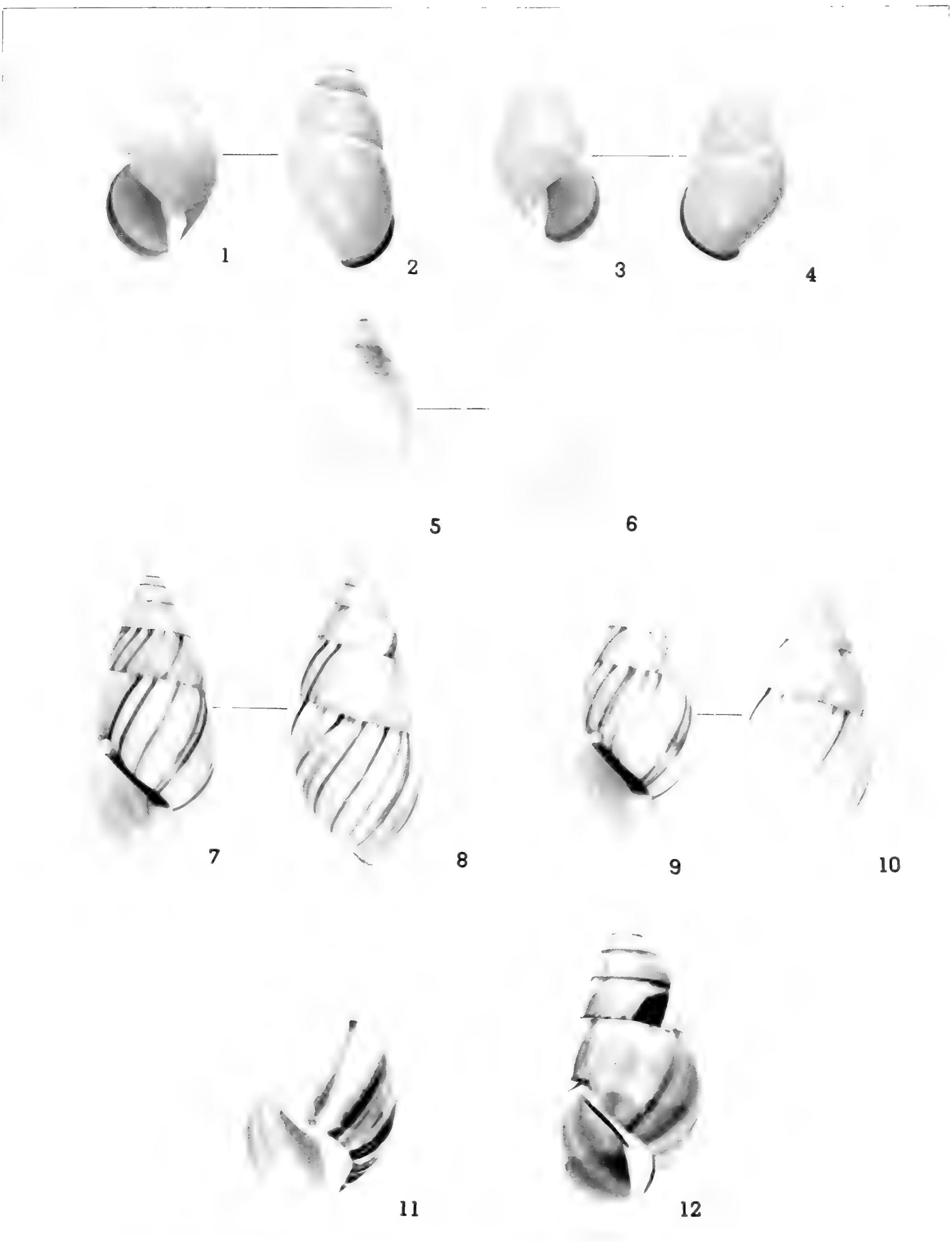
	mean	range	standard deviation
height (mm)	35.73	30.8-42.2	2.22
breadth (mm)	20.38	18.4-23.3	1.31
height of aperture (mm)	19.51	17.3-21.1	0.94
height of last whorl (mm)	26.31	23.0-28.7	1.37
h/b	1.757	1.60 - 2.08	0.106
ha/h	0.548	0.48 - 0.58	0.020
lw/h	0.737	0.69 - 0.78	0.024
number of whorls	5.583	5.25 - 6	0.175
perch angle (°)	28.95°	27° - 32°	1.112°

Table 2. *Amphidromus (Amphidromus) puspae.* Shell measurements.

	Holotype (MZB)	Paratype (ZMA)	Paratype (SMF)
height (mm)	59.4	53.5	53.9
breadth (mm)	28.3	27.1	27.4
height of aperture (mm)	27.4	27.1	26.5
height of last whorl (mm)	37.6	34.3	36.2
h/b	2.099	1.974	1.967
ha/h	0.461	0.507	0.492
lw/h	0.633	0.641	0.672
number of whorls	6.50	6.25	6.25
perch angle (°)	27	30	28
shape	sin.	dex.	sin.

FIGURES (opposite)

1-4. *Amphidromus (Amphidromus) djajasasmitai*
1-2.Holotype (MZB), h = 36.8 mm.
3-4. Paratype (ZMA), h = 34.5 mm.
5-6. *Amphidromus (Amphidromus) alticola* Fulton, 1896
(author coll.), Pangalengan, West Java, h = 34.1 mm.
7-10. *Amphidromus (Amphidromus) puspae*
7-8. Holotype (MZB), h = 59.4 mm;
9-10. Paratype (SMF), h = 53.9 mm.
11. Yellow *Amphidromus (Amphidromus) javanicus* Sowerby, 1841
(author coll.), Malimping, West Java, h = 57.8 mm.
12. *Amphidromus (Amphidromus) inversus inversus* Müller, 1774
(author coll.), Kotabumi, Lampung, South of Sumatra, h = 60.3 mm.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Description of two new species of *Haustellum* Schumacher, 1817 (Gastropoda: Muricidae) from the Western Indian Ocean.

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KEYWORDS: Mollusca, Gastropoda, Muricidae, *Haustellum*, new species.

ABSTRACT: *Haustellum langleitae* is described from Tanzania and Madagascar, and *H. barbieri* is described from Madagascar. The two species are compared with related taxa from the Indo-West Pacific.

RESUME: Deux nouvelles espèces du genre *Haustellum* Schumacher, 1817 sont décrites. *H. langleitae* n.sp. provient de Tanzanie (région de Dar-es-Salaam) et de Madagascar, tandis que *H. barbieri* n.sp. est actuellement connu uniquement de la localité type, située à Madagascar. Les deux nouveaux taxa sont comparés à des espèces apparentées de l'Indo-Pacifique.

Abbreviations

IRSNB - Institut Royal des Sciences Naturelles de Belgique, Bruxelles.

MNHN - Muséum National d'Histoire Naturelle, Paris, France.

SYSTEMATICS

Family Muricidae Rafinesque, 1815
Subfamily Muricinae Rafinesque, 1815
Genus *Haustellum* Schumacher, 1817

Haustellum langleitae n.sp.
Figs 5, 10-12

Type Material

Sinda Island, Tanzania, 1980 (holotype IRSNB 28.008/462); Dar-es-Salaam, Tanzania, June 1982 (1 paratype MNHN; 1 paratype NM L1061/T999; 4 paratypes (including 2 juveniles) coll. R. Houart.

Other Material Examined

Sinda Island, Tanzania, 1980, 1 sp., coll. A. Langleit; Tanzania (no other data), 1982, 1 sp., coll. A. Langleit; Madagascar (no other data), 1 sp., coll. R. Houart; Madagascar, 1 sp., coll. F. Franchi.

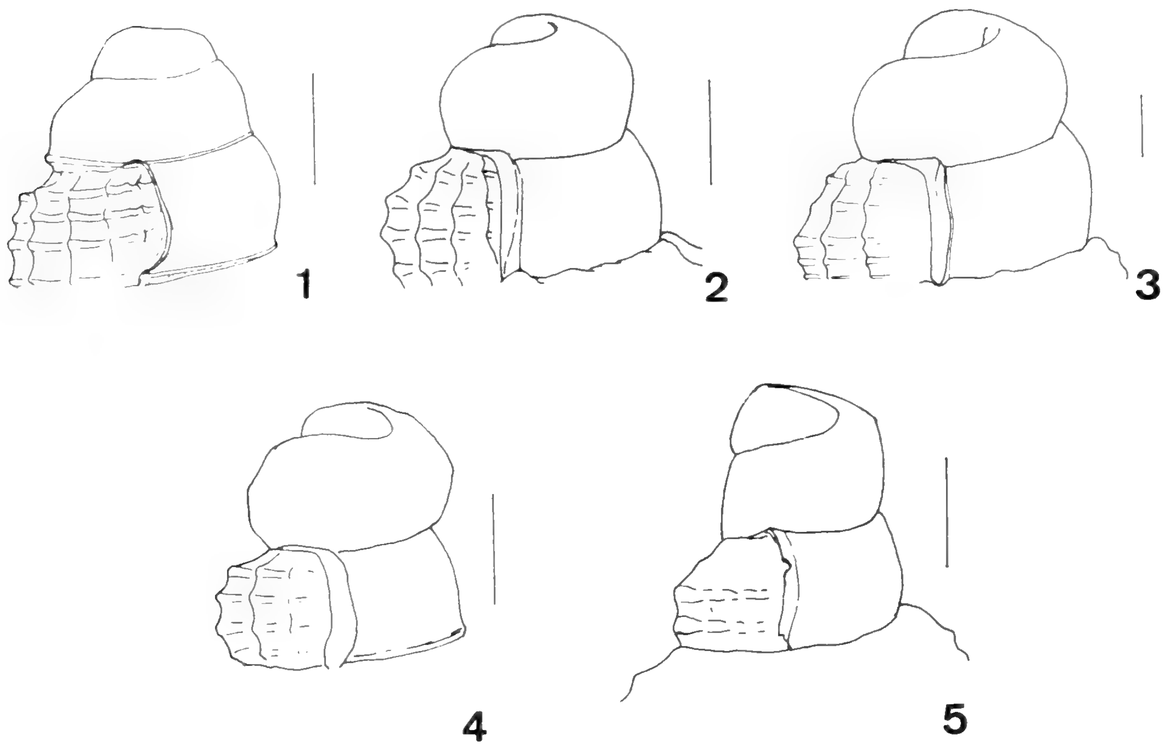
Description

Shell heavy, medium sized for the genus, up to 94.10 mm in length at maturity (paratype R. Houart). Spire moderately high with 2.5 protoconch whorls and up to 8 shouldered, tuberculate teleoconch whorls with impressed suture. Protoconch smooth, weakly shouldered, high, terminal varix raised, weakly curved. First to third teleoconch whorls with 13 or 14 nodose axial ribs; fourth teleoconch whorl with nodose axial ribs and earliest varices; fifth to last teleoconch whorls with 3 varices, 3 axial tuberculate ribs between each pair of varices. Last teleoconch whorl with heavy rounded varices and occasionally with only 2 heavy axial ribs between them. No

other axial sculpture. Spiral sculpture consisting of numerous, mostly low and indistinct, narrow threads, more strongly developed on nodes of the axial ribs. Aperture rounded with flaring, smooth, columellar lip; outer lip smooth, erect, weakly lirate within; anal notch weak. Siphonal canal long, straight, narrowly open, smooth. Shell greyish-brown with bluish-black or brown blotches on the spire, and on the siphonal canal. Aperture whitish with light yellow or pink traces on the columellar lip and on the lirations inside aperture.

Remarks.

Already illustrated and commented, by HOUART (1990: 333), *H. langleitae* differs from *H. haustellum* in the more elongate, weakly shouldered and non-carinate protoconch, in the spineless siphonal canal, the more numerous axial ribs on the first teleoconch whorl (10-12 on 2 first whorl and 12-14 on third in *H. haustellum*), and in the higher and heavier varices on last teleoconch whorl. Other species such as *H. longicaudus* (Baker, 1891), *H. fallax* (Smith, 1891), *H. kurodai* (Shikama, 1964), and *H. vicdani*



Figures 1-5. Protoconchs (scale bars 0.5 mm)
1. *Haustellum haustellum* (Linné, 1758), New Caledonia, MNHN.
2. *Haustellum kurodai* (Shikama, 1964), Philippine Ids, coll. R. Houart.
3. *Haustellum fallax* (Smith, 1891), Mozambique, coll. R. Houart.
4. *Haustellum longicaudus* (Baker, 1891), Ethiopia, coll. R. Houart.
5. *Haustellum langleitae* n.sp., Madagascar, coll. R. Houart.

(Kosuge, 1980) all differ in protoconch characters (see Figs 1-4), thickness of varices, ornamentation of the siphonal canal and even if of lesser importance, in the shell colour.

Of all above cited species four are present in the Western Indian Ocean: *H. fallax*, *H. haustellum*, *H. longicaudus* and *H. langleitae*. *H. franchii* Bozzetti, 1993 was named from off Somalia (BOZZETTI, 1993: 107). The remaining species, *H. kurodai* and *H. vicdani*, apparently have restricted geographical distributions, from the Philippine Islands to south of Japan. One species, *H. haustellum* has a wide IndoWest Pacific distribution, certainly due to its planctotrophic larval development.

Unlike to PONDER & VOKES (1988) I prefer to treat all of these taxa as separate species, primarily on the basis of protoconch (except for *H. vicdani*) and shell characters.

Etymology

Named after Annie LANGLEIT (Brussels) an enthusiastic shell collector, who first brought the species to my attention some years ago.

Haustellum barbieri n.sp.
Figs 6, 7-9

Type Material

Sainte-Marie (Nosy-Boraha), Madagascar, in fisher nets, 30-35 m (holotype MNHN; 1 paratype coll. R. Houart).

Description

Shell medium sized for the genus, up to 90.4 mm in length, heavy, tuberculate. Spire moderately high with 7 broad, shouldered teleoconch whorls. Protoconch unknown (broken). Suture impressed. First teleoconch whorl lightly eroded; second whorl with 20-22 low, rounded axial ridges; third whorl with rounded axial ridges and earliest varices; fourth to sixth teleoconch whorl with 3 rounded, tuberculate varices, 4 (occasionally 3) nodose, axial ridges between each pair of

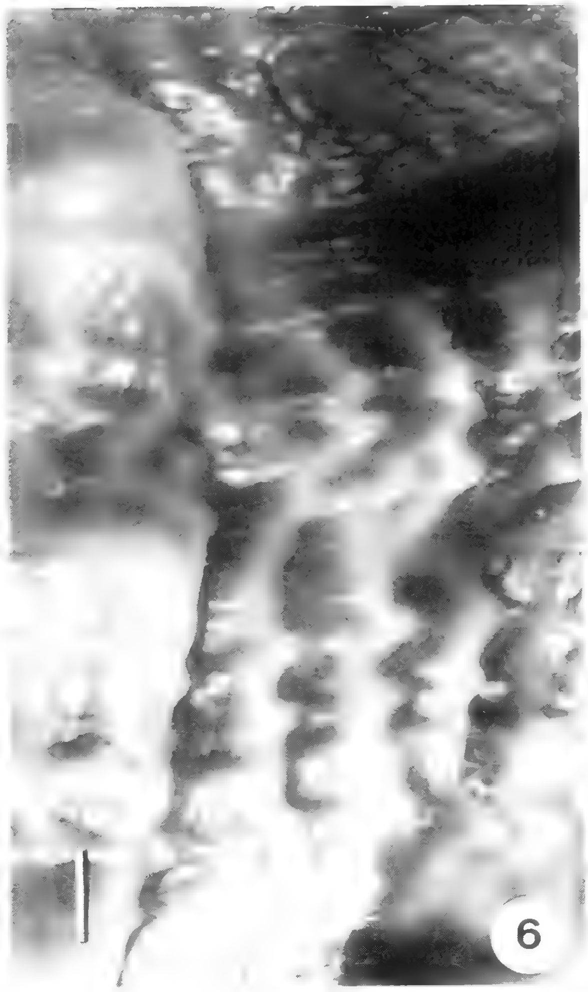


Figure 6.
Haustellum barbieri n.sp., holotype, detail of surface sculpture (scale bar 1 mm).

varices. Last teleoconch whorl with 3 tuberculate varices and 4 axial ridges between them. Other axial sculpture consisting of very narrow, nodose, irregular, rounded threads. Spiral sculpture of last teleoconch whorl consisting of 8 cords, more strongly developed on axial ridges: 2 cords on shoulder; 4 higher cords on body; 2 lower and narrower cords abapically. Other spiral sculpture consisting of numerous, narrow, rounded threads. Aperture rounded with flaring, smooth, columellar lip; outer lip erect, smooth within; anal notch weak. Siphonal canal long, straight, narrowly open, ornamented with 5 high, rounded, spiral cords. Shell pinkish brown with darker blotches on spiral cords and lighter coloured axial threads. Aperture glossy white.

Etymology.

Named after Jean-Pierre BARBIER (Paris), who sent the specimens for study and kindly donated the type material.

Remarks.

Haustellum barbieri recalls *H. tweedianus* (Macpherson, 1962) from Queensland, Australia in the pinkish colour and wrinkled micro-sculpture. However, *H. barbieri* differs from the latter in having a spineless siphonal canal, rounded apertural varix, relatively smooth outer apertural lip, more nodose and more numerous axial ridges, and flaring, strongly erect columellar lip. *H. barbieri* differs from any other species of *Haustellum* in the particular colour and micro-sculpture, sculpture of siphonal canal and very nodose shell.

Acknowledgements.

I am particularly indebted to J.P. Barbier (Paris, France), F. Franchi (Piacenza, Italy) and A. Langleit (Brussels, Belgium) for the loan and gift of specimens. Thanks also to B.A. Marshall (Museum of New Zealand) and to E.H. Vokes (Tulane University) for their remarks on *Haustellum langleitae*.

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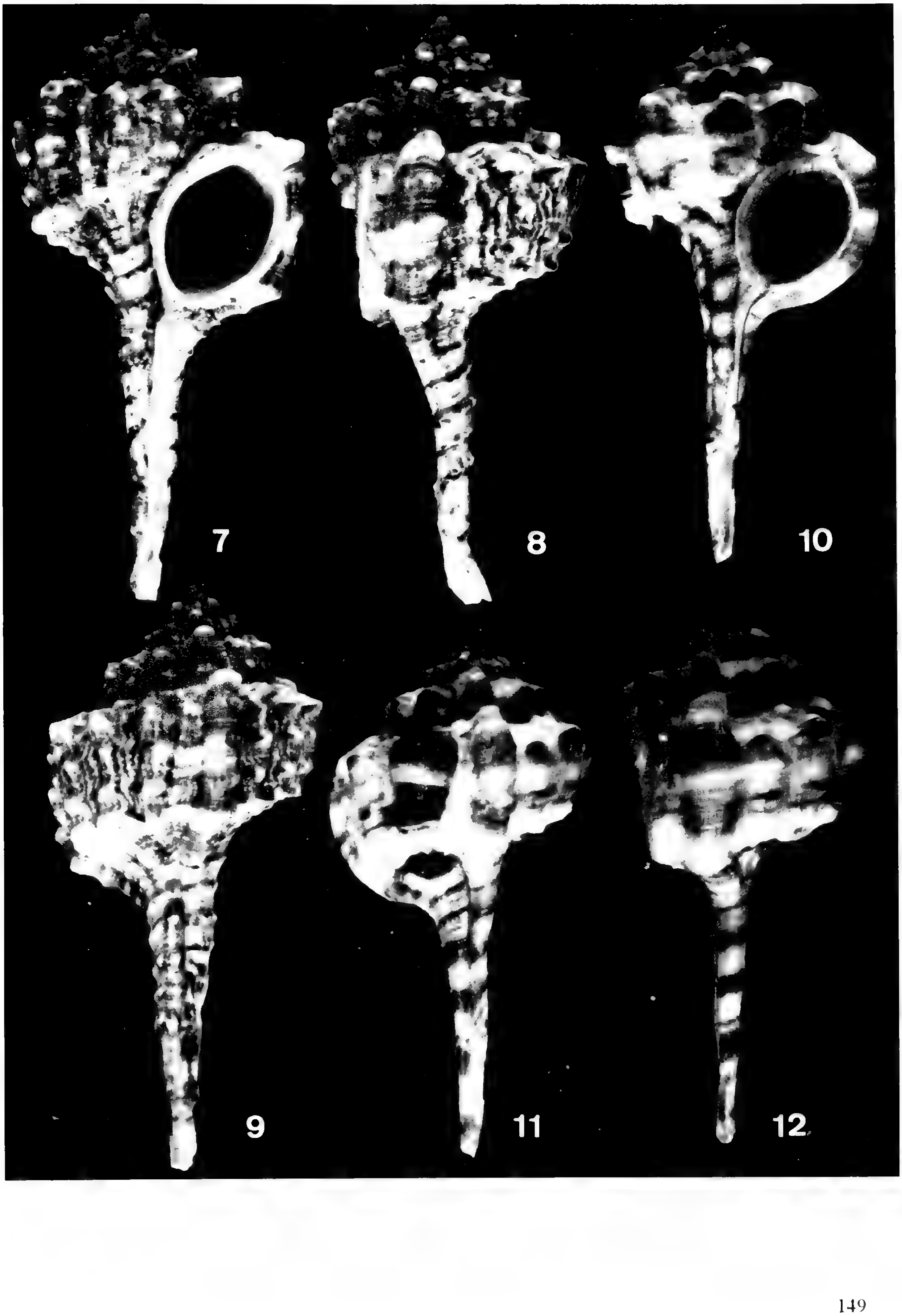
Figures 7-12. (opposite)
7-9. *Haustellum barbieri* n.sp., holotype MNHN, Sainte Marie (Nosy-Boraha), Madagascar, 86 mm.
10-12. *Haustellum langleitae* n.sp., holotype IRSNB 28.008/462, Sinda Island, Tanzania, 73 mm.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Studies on Olividae XVII. Data on depth of burrowing, motion and substrate choice of some *Oliva* species.

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ABSTRACT. The depth of burrowing of several *Oliva* species has been measured. The influence of several parameters (size and colour of the shell, nature of substrate, day-night effect) on movement has been tested and discussed. Substrate choice experiments have been performed on adult *Oliva* of different species.

RESUME. La profondeur d'enfouissement de plusieurs *Oliva* a été déterminée. L'influence de plusieurs paramètres (taille et couleur de la coquille, nature du substrat, effet jour-nuit) sur le mouvement a été testée et discutée. Des expériences de choix de substrat ont été effectuées sur des *Oliva* adultes de plusieurs espèces.

KEYWORDS: Mollusca, Gastropoda, *Oliva*, behaviour, depth of burrowing, choice of substrate, motion.

1. PURPOSE

The purpose of the present work was threefold:

1. We needed to establish the burrowing depth of *Oliva*, in order to optimize our sampling methods for a quantitative field investigation on the distribution of species.

2. "Substrate preferences" have been reported for some species by several field collectors (HEMMEN, 1981; WIDMER, 1981 and WITTIG-SKINNER, 1981) as well as GREIFENEDER (1981) and PETUCH & SARGENT (1986). We wanted to determine whether habitat specificity could be explained by an active choice of the substrate by adult *Oliva*.

3. *Oliva* are widely reported to be "particularly active at night" (see for instance ZEIGLER & PORRECA, 1969; PETUCH & SARGENT, 1986). Such information is not very informative about the nature of that activity and we wished to obtain comparative day and night data on a specific action, in this case mobility.

2. MATERIAL AND EXPERIMENTAL CONDITIONS

All experiments were carried out at King Leopold III Biological Station at Laing Island (4°10'30"" S, 144°52'47" E), in Hansa Bay, Papua New Guinea. White painted (epoxy) marine plywood aquaria, equipped with an open circulation of natural seawater flowing slowly from a storage tank, were placed under an open corrugated iron shelter shaded with curtains of fishing net. The light uniformity was checked with a luxmeter and the water

Contribution n° 282, Station Biologique Léopold III, Laing Island, Papua New Guinea

temperature was close to that in the bay. Specimens were individually tagged as in previous experiments in Brussels (see TURSCH, 1991) by numbering them with red nail varnish (Bourgeois, Pourpre). *Oliva* appear unaffected by this treatment and the tags lasted several weeks. Olives were fed once a week with meat morsels. All specimens were acclimatized more than 4 days before observations. Two different sediments (one black, terrigeneous, fine sand of volcanic origin and one white, coarse coral sand, both typical of the two general classes of sediments found in Hansa Bay) were utilized for substrate effect experiments.

For estimation of the burrowing depth we have utilized the common species *O. carneola* Gmelin, 1791, *O. coerulea* Röding, 1798, *O. longispira* Bridgman, 1906, *O. reticulata* Röding, 1798 and *O. sericea* Röding, 1798 in order to examine species with very different sizes.

For experiments on night/day mobility we have utilized: *O. carneola* (very largely represented on different types of substrate) and *O. longispira* (restricted to sandy beaches). As we wanted to see if activity varies with size within a given species *O. carneola* of two size classes were utilised (small specimens from 9.3 mm to 11.2 mm and large ones from 14.3 mm to 18.9 mm). The same was done for *O. longispira* (small specimens from 13.3 mm to 22.8 mm and large ones from 31.3 mm to 42.0 mm). It is to be noted that *O. longispira* is represented in Hansa Bay by two populations: one lives on white sand and all specimens are white; the other lives on black sand and 75% of the specimens are black. Black and white specimens of this species were compared, in order to see if activity is correlated with shell colour.

For experiments on substrate choice we have utilized: *O. carneola*, *O. coerulea* and *O. longispira*. All *O. carneola* and *O. coerulea* in these experiments were collected during March and April 1991 in the coarse white coral sand from Laing Island lagoon and all *O. longispira* in the black sand of Sisimangum beach, excepted for the large white specimens, collected on white sand at Boro Beach.

3. EXPERIMENTS ON THE BURROWING DEPTH OF *OLIVA*

3.1. Method

Experiments were performed in daylight in small aquaria (26 cm x 14 cm x 13 cm). Both black and white substrates were tested. Preliminary experiments established that a 8 cm bottom layer of sand was sufficient. 2 to 5 specimens (depending on size) were placed on the substrate, in which they soon burried. When burried specimens were close enough to the glass plate of the aquarium, one could measure without disturbance the distance separating their metapodium from the sand surface.

After these observations and while the olives were still burried, we lowered the water level (to 2 or 3 cm under the surface) by tilting the aquarium without disturbing the sand layer, in order to very roughly simulate a receding tide. The reaction of each animal was then observed for more than 30 minutes.

3.2. Results

Depth of burial was similar in both substrates but for most tested species was significantly deeper in white coarse sand. None of the species burried in the substrate by more than 5.5 cm. Observations in both sediments were thus grouped and are reported in Table 1. Lowering the water level does not seem to cause deeper burial but on the contrary appears to trigger a tendency to emergence.

4. EXPERIMENTS ON MOBILITY

4.1. Purpose.

The experiments were designed to answer four questions, for each of which the null hypothesis (H_0) is given hereunder.

Question 1: **Substrate effect**. $H_0 1$: Motion is the same whatever the nature of the sediment where motion begins (comparison of substrate effect within each category of shell size and color).

Question 2: **Size effect.** $H_0 2$: Motion is the same for small and large specimens.

Question 3: **Day/night effect.** $H_0 3$: Motion is the same during the day and the night.

Question 4: **Color effect**. $H_0 4$: Motion is the same whatever the colour of the specimens in the case of *O. longispira* (presenting a colour polymorphism).

These null hypotheses have been tested with the usual non-parametric $\chi^2(2x2)$ tests.

4.2. Material and method.

Aquarium: 50 cm x 34.5 cm. Water height: 25 cm. The bottom of the aquaria were divided in eight equal rectangular compartments separated by small plastic walls (22 mm height and 3.5 mm width). Sediments tested: black and white sand (see section 2). Each compartment was filled with a 2 cm layer (enough to allow specimens to bury) of substrate, in such a way as to divide the bottom of the aquarium into two halves, each being covered by one type of sediment.

At the start of each experiment half of the specimens are placed in each type of substrate. Evey recorded passage of an animal from one compartment to another is considered a motion. For 8 days the location of the *Oliva* was recorded twice daily: once in the morning (6 - 7.00 a.m., to observe night activity) and once in the evening (18.00 p.m, for day activity). Burried *Oliva* are hard to find and occasionally some specimen(s) (especially of small size) could not be located. All calculations are therefore made on the basis of the number of specimens for which motion could actually have been observed, this is the number of specimens located both before and after each time lapse (called "Σ observations" in the tables). Non parametric Chi square tests were performed on the number of animals that moved and the number that did not. As we are dealing with small figures, we only consider the 0.01 significance level, for the sake of precaution.

4.3. Experiment on *O. longispira.*

4.3.1. Experimental conditions. 12 small (see section 2) and 5 large (see section 2) specimens of each colour (black and white) were utilised. Water current resulted from two water flows: a weak one in the white sediment and another, somewhat stronger, between the two sediments.

4.3.2. Results. The results of this experiment are summarized in Table 2. One sees that:

a. The nature of the substrate does not influence the motion of *O. longispira*. For the following χ^2 tests, this result allows to group the counts for each category of animals, irrespective of the nature of the substrate in which motion originates.

b. Motion varies with the size classes of the specimens. During the day small olives are active while large ones are totally motionless. No significant difference between the size classes is noted during the night.

c. All categories of olives are more mobile during the night than during the day.

d. Motion is not related to the colour of the shell.

4.4. Experiment on *O. carneola.*

4.4.1. Experimental conditions. 11 specimens of each size class (see section 2) were utilised. Water flow very low, parallel to the aquarium length. White sand upstream.

4.4.2. Results. The results of these experiments are summarized in Table 3.

a. Here also, the nature of the substrate does not influence the motion of *O. carneola*. For the following tests, this result allows to group the counts for each category of animals, irrespective of the nature of the substrate in which motion originates.

b. Motion does not vary with the size classes of the specimens, contrary to the case of *O. longispira*.

c. All categories of olives, here again, are more mobile during the night than during the day

5. EXPERIMENTS OF SUBSTRATE CHOICE

5.1. Material and method

The bottom of the test aquarium is divided into two halves, each containing one of the two sediments to be tested. Sediments tested: black and white sand (see section 2). The sediments are contiguous, not separated by any physical obstacle, in order to allow the olives to effect their choice in a situation where they are in actual contact with both types of sediment. Half the *Oliva* sample is deposited in each type of sediment at the start of the experiment. Counts of presences (not motion !) in each sediment are effected every morning and evening. A specimen found on the borderline between sediments is counted as a 0.5 presence in each of the sediments.

5.2. Experiments on *O. carneola*

5.2.1. Experimental conditions. Aquarium: 50 cm x 34.5 cm. Water height: 25 cm. Thickness of sediment : 1.5 cm (enough to cover the specimens).16 specimens of each size class (see section 2) were utilised. Water flow perpendicular to border between sediments. The experiment is repeated after inverting the relative position of the two substrates, in order to account for a possible rheotaxis already evidenced in *Oliva vidua* (TURSCH, 1991).

5.2.2. Results. The results of these experiments are summarized in Table 4 (white sand upstream) and 5 (white sand downstream). There were no highly significant differences in the observed behaviour of the size classes (see VAN OSSELAER, 1992 for details). The χ^2 test being very sensitive to the size of the samples, only global figures are reported in the tables.

Two cases are observed: either *O. carneola* chooses the white substrate or its choice is not significant. Even when significant, the overall choices (58.2% and 53.4%) are only marginal.

5.3. Experiment on *O. coerulea*

5.3.1. Experimental conditions. Aquarium: 60 cm x 24 cm. Water height: 35 cm. Thickness of both sediments: 2.5 cm (enough to cover specimens). 10 specimens were utilised. Water flow parallel to border between sediments. Inversion of sediments is thus not necessary.

5.3.2. Results. The results of these experiments are summarized in Table 6. *O. coerulea* has a highly significant preference for white sand but this choice is marginal (57.6 %).

5.4. Experiments on *O. longispira*

5.4.1. Experimental conditions. Aquarium: 50 cm x 34.5 cm. Water height: 25 cm. Thickness of both sediments: 0.5 cm (not enough to completely cover specimens). 5 specimens (large size class, see section 2) of each colour (black and white) were utilised. Very low water flow not parallel to border between sediments. Repetition of the experiment with inversion of sediments was deemed necessary.

5.4.2. Results. The results of these two experiments being not significantly different (see VAN OSSELAER, 1992); the pooled results are presented in Table 7. The choice of black olives is always non significant. White olives have a highly significant overall choice for the black substrate (in which they are not concealed and which is not their substrate of origin !). Here again, the choice is only marginal (64%). On the total, the difference between the behaviour of black and white olives is confirmed by a highly significant χ^2 (2x2) test.

6. CONCLUSIONS AND DISCUSSION

Burrowing. The present results indicate that examination of the first 5-6 cm of

substrate is sufficient for a reliable quantitative sampling of *Oliva*. This is in agreement with a large number of field observations and has a direct bearing on the planning of quadrat studies and in the design and utilisation of dredges.

As reported above, most species bury deeper in white, coarse sand but the difference does not exceed 1.6 cm.

Motion. The motions observed in these experiments are minimal estimates. Our figures do not account for the specimens possibly returning to the initial compartment after a motion, nor for their motion inside a given compartment. In addition, if the border effect previously demonstrated for *Oliva vidua* (TURSCH, 1991) is effective here, it would restrict the passage of borders. These considerations equally affect every single experiment but do not modify the validity of the conclusions: at this stage our purpose is not to quantify actual mobility but to compare mobility under various parameters (size, colour of the shell, nature of substrate, day and night).

In the cases examined, motion was higher during the night than during the day and did not seem to vary with the nature of the substrate. For the colour polymorphic *O. longispira*, it did not vary with the colour of the shell. At least in some cases (for example *O. longispira* during the day) activity can vary with the size of the shell.

Choice of substrate. Substrate preferences (when they can be evidenced at all) can be highly significant but never overwhelming (a marginal majority of 61.1% of the specimens, at best). Many species of *Oliva* are restricted to a given type of substrate and the reasons for that specificity are still entirely unknown. The present results indicate it is unlikely that this restriction of habitat is caused by a choice of substrate by adult specimens. The possibility that sediment specificity could be explained by the occurence of a specific food in a given substrate is also unconvincing. *Oliva* are catholic carnivores and although they will occasionally specialize in a readily available food (FOTHERINGHAM, 1976) they are not fussy eaters. *Oliva* of several species have been easily maintained for years in our laboratory and did produce larvae on a variety of diets that are unusual for them.

It is to be noted that when white specimens of *O. longispira* exhibited a (weak) preference for a black substrate, the choice was made at night. It is thus improbable that the choice of sediment was made on the basis of colour. Surface features and/or granulometry are more likely to intervene in the choice.

Acknowledgements

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Table 1. Burrowing depth.

Species	Shell Max. Diameter (mm)	n	Burrowing depth Min (cm)	Max (cm)	Mean (cm)	Reaction to lowering water level
O. carneola	9.7	33	1	3	1.6	move to surface (no emergence)
O. coerulea	14.1	15	1.5	4	2.2	move to surface (no emergence)
O. longispira (< 22.8 mm)	6.7	23	0.5	2	1.3	move to surface (no emergence)
O. longispira (> 31.3 mm)	13.1	28	1	4	2.7	move to surface (no emergence)
O. reticulata	15.9	17	1.5	4	3.2	no reaction
O. sericea	25	16	2.5	5.5	3.4	emergence of all specimens

n: number of observations.

Table 2. Motion of *Oliva longispira*.

	***Oliva* categories**	Small white	Small white	Small black	Small black	Large white	Large white	Large black	Large black
	Departure sediment	black	white	black	white	black	white	black	white
	Σ observations	34	30	40	29	16	14	13	17
	Σ motions	9	8	6	4	0	0	0	0
	Σ no motion	25	22	34	25	16	14	13	17
D	% motion	26.5	26.7	15.0	13.8	0.0	0.0	0.0	0.0
A	**$H_0 1$: χ^2 (2x2)**	NS		NS		NS		NS	
Y	**$H_0 4$: χ^2 (2x2)**	NS				NS			
	$H_0 2$: χ^2 (2x2)				**				
							**		
	Σ observations	29	22	33	26	13	12	12	13
N	Σ motions	16	14	23	10	10	9	7	5
I	Σ no motion	13	8	10	16	3	3	5	8
G	% motion	55.2	63.6	69.7	38.5	76.9	75.0	58.3	38.5
H	**$H_0 1$: χ^2 (2x2)**	NS		*		NS		NS	
T	**$H_0 4$: χ^2 (2x2)**	NS				*			
	$H_0 2$: χ^2 (2x2)				NS				
							NS		
	$H_0 3 \chi^2$ (2x2)	**		**		**		**	

NS: non significant; *: significant (at the 0.05 level); **: highly significant (at the 0.01 level).

Table 3. Motion of *O. carneola*.

	DAY				NIGHT			
***Oliva* categories**	Small	Small	Large	Large	Small	Small	Large	Large
Departure sediment	black	white	black	white	black	white	black	white
Σ observations	29	28	35	28	35	38	43	37
Σ motions	6	7	4	3	17	20	28	23
Σ no motion	23	21	31	25	18	18	15	14
% motion	20.1	25.0	11.4	10.7	48.6	52.6	65.1	62.2
$H_0$1: χ^2 (2x2)	NS		NS		NS		NS	
$H_0$2: χ^2 (2x2)	NS				NS			
$H_0$3: χ^2 (2x2)	**							
	**							

NS: non significant; *: significant (at the 0.05 level); **: highly significant (at the 0.01 level).

Table 4. Substrate choice by *O. carneola* (white sand uptream).

	Black Substrate	White Substrate	χ^2
Day	63.5 (40.7%)	98.5 (59.3%)	**
Night	81.5 (44.0%)	103.5 (56.0%)	NS
Day & Night	145 (41.8%)	202 (58.2%)	**

NS: non significant; **: highly significant (at the 0.01 level).

Table 5. Substrate choice by *O. carneola* (white sand downstream).

	Black Substrate	White Substrate	χ^2
Day	97.5 (55.7%)	77.5 (44.3%)	NS
Night	80.5 (38.9%)	126.5 (61.1%)	**
Day & Night	178 (46.6%)	204 (53.4%)	NS

NS: non significant; **: highly significant (at the 0.01 level).

Table 6. Substrate choice by *O. coerulea*.

	Black substrate	White substrate	χ^2
Day	57 (43.9%)	73 (56.1%)	NS
Night	65.5 (41.0%)	94.5 (59.0%)	*
Day & Night	122.5 (42.4%).	167.5 (57.6%)	**

NS: non significant; *: significant (at the 0.05 level); **: highly significant (at the 0.01 level).

Table 7. Substrate choice by *O. longispira*.

	Black substrate	White substrate	χ^2	χ^2 (2x2)
white / Day	43 (61.4%)	27 (38.6%)	NS	
white / Night	53 (66.2%)	27 (33.8%)	**	
black / Day	32 (45.7%)	38 (54.3%)	NS	
black / Night	37 (46.2%)	43 (53.7%)	NS	
white / Day & Night	96 (64.0%)	54 (36.0%)	**	**
black / Day & Night	69 (46.0%)	81 (54.0%)	NS	

NS: non significant; **: highly significant (at the 0.01 level).

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